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ABSTRACT

This manual was developed to provide guidance to individuals working in Project SOAR (Stress on Analytical Reasoning), a pre-freshman summer program for science majors anticipating matriculation at Xavier University of Louisiana. Following an overview of Xavier University and Project SOAR and an outline of general instructions, specific instructions are provided for Piagetian-based laboratory experiments, computer programming, cognitive therapy, vocabulary, and quiz bowl competitions. A general description, materials needed, and comments on exploration/invention/application are provided for each of the 20 SOAR experiments, organized as learning cycles. The experiments (five each from biology, chemistry, physics, and mathematics) were developed to stress five major problem-solving components (Piagetian formal operations): control of variables, proportional reasoning, combinatorial reasoning, probability, and recognizing correlations between variables. Schedules, general comments, and instructional strategies for instructors and group leaders are provided for computing programming, cognitive therapy, vocabulary-building sessions, and quiz bowl competitions (designed as a motivational strategy). (Author/JN)

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INSTRUCTOR'S MANUAL

for

Project

SOAR

(Stress On Analytical Reasoning)

Spring, 1981

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Preface

This document was developed to provide guidance to individuals working in Project SOAR (Stress On Analytical Reasoning), a pre-freshman summer program for science majors anticipating matriculation at Xavier University of Louisiana. It was developed through the efforts of the following individuals from Xavier and local high schools who have served as faculty in the indicated components of the program:

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TABLE OF CONTENTS

OVERVIEW

1.1 Overview of Xavier University....1
1.2 Overview of Project SOAR....3

GENERAL INSTRUCTIONS

2.1 All Personnel....7
2.2 XU and High School Math/Science Faculty....7
2.3 Medical/Dental Student Group Leaders....8

INSTRUCTIONS FOR PIAGETIAN-BASED LABORATORY EXPERIMENTS

3.1 General....11
3.2 Biology:
a--General....14
b--Control of Variables....15
c--Proportional Reasoning....17
d--Combinatorics....19
e--Probability....22
f--Correlational Reasoning....25
3.3 Chemistry:
a--General....29
b--Control of Variables....30
c--Proportional Reasoning....32
d--Combinatorics....34
e--Probability....36
f--Correlational Reasoning....38
3.4 Mathematics:
a--General....40
b--Control of Variables....41
c--Proportional Reasoning....45
d--Combinatorics....47
e--Probability....49
f--Correlational Reasoning....51
3.5 Physics:
a--General....53
b--Control of Variables....54
c--Proportional Reasoning....56
d--Combinatorics....58
e--Probability....60
f--Correlational Reasoning....62

INSTRUCTIONS FOR COMPUTER PROGRAMMING

4.1 Instructors

(continued)

INSTRUCTIONS FOR COGNITIVE THERAPY

5.1 General....65
5.2 Group Leaders
a--Analytical Reasoning....68
b--Problem-Solving....70
c--Tutorial Sessions....71
5.3 Supervisor: Analytical Reasoning & Problem-Solving....72

INSTRUCTIONS FOR VOCABULARY

6.1 General....73
6.2 Group Leaders....74
6.3 Supervisor....75

INSTRUCTIONS FOR QUIZ BOWL COMPETITIONS

7.1 General....76
7.2 Group Leaders....77
7.3 Supervisor....78
7.4 Graders....79

APPENDICES

I--SOAR Weekly Summary Sheet
II--Rules for Quiz-Bowl Competitions
III--Quiz-Bowl Summary Sheet
IV--Answers to Homework Assignments
V--Vocabulary Quizzes

OVERVIEW

1.1 Overview of Xavier University of Louisiana

Xavier University of Louisiana is a small, predominantly black institution located in the approximate geographic center of the City of New Orleans. In the fall of 1980, its total enrollment is 2003 of which approximately 15% is non-Black and approximately 925 are enrolled in a natural, health, or mathematical science major. The specific enrollment by area was as follows:

Biology	139
Chemistry	155
Mathematics/Computer Science	95
Physics/Pre-Engineering	75
Medical Technology	100
Pre-Pharmacy	177
Pharmacy	189
Total	930

The University's primary mission is to provide educational opportunities to Black Americans with emphasis on residents of the Gulf South. Xavier's institutional philosophy might be summarized as "standards with sympathy"--a commitment to accept many students with discernible academic weaknesses coupled with an equally strong commitment to demand a high standard of performance for graduation and to provide the support services which makes it possible for disadvantaged students to attain success.

Xavier's past peformance is best exemplified by the outstanding success of its alumni who include:

The Honorable Ernest "Dutch" Morial, Mayor of the City of New Orleans, the first Black American to be elected to that position.

Ms. Mary Munson Runge, President of the American Pharmaceutical Assocation, the first Black and first female to hold that position and member of President Reagan's Advisory Committee for Health and Science.

Mr. Joseph Hall, President of the National Pharmaceutical Assocation. (With Mr. Hall's election, Xavier became the only institution to have alumni simultaneously serve as presidents of the two major pharmaceutical associations.)

Dr. Claude Organ, M.D., Chairman and Professor of the Department of Surgery at Creighton Medical School.

Dr. Joseph Henry, Jr., D.D.S., Associate Dean, Harvard School of Dental Medicine, the first Black to hold such a position at Harvard.

Dr. Joyce Verrette, the scientist who discovered the carcinogenic nature of cyclamate and led the effort to discontinue its use as an artificial sweetner.

The University also continues its record of achievement today as indicated by the following representative statistics from the sciences for more recent years.

1. In the past six years, 85 of 100 XU students who applied to medical or dental school gained admittance. This acceptance rate, 85%, is more than twice the national average over that period.

2. In 1978-79 and 1979-80 alone, XU placed approximately 125 students into medical, dental, pharmacy, or science graduate schools.

3. Xavier's College of Pharmacy is the only such facility in soutern Louisiana. The pass-rate of XU graduates on the Louisiana State Board of Pharmacy is higher than that of non-XU graduates over the past three years (the only time period for which state-wide data is available).

4. In 1977-78, a Chemistry graduate from Xavier was the only student from a Louisiana institution to receive a prestigious Danforth Fellowship for graduate study.

1.2 Overview of Project SOAR

The best overview of Project SOAR is the "Special Report" which appeared in the December 9, 1980, issue of TWAX (This Week At Xavier), the University's weekly newsletter. It is reproduced on the following two pages. The following weekly schedule provides a pictorial representation of the manner in which the various activities in SOAR fit together.

	Monday	Tuesday	Wednesday	Thursday	Friday
8:30	Tutorial Assistance	Tutorial Assistance	Tutorial Assistance	Tutorial Assistance	Tutorial Assistance
9:00	Biology (1*)	Biology (2)	Biology (3)	Biology (4)	Biology (5)
	Chemistry (2)	Chemistry (3)	Chemistry (4)	Chemistry (5)	Chemistry (1)
	Computer Programming (3)	Computer Programming (4)	Computer Programming (5)	Computer Programming (1)	Computer Programming (2)
	Math (4)	Math (5)	Math (1)	Math (2)	Math (3)
	Physics (5)	Physics (1)	Physics (2)	Physics (3)	Physics (4)
12:00	Lunch	Lunch	Lunch	Lunch	Lunch
1:00	Analytical Reasoning	Analytical Reasoning	Analytical Reasoning	Analytical Reasoning	Group Contest!!!
1:45	Problem-Solving	Problem-Solving	Problem-Solving	Problem-Solving	
2:30	Vocabulary	Vocabulary	Vocabulary	Vocabulary	
3:00	Tutorial Assistance	Tutorial Assistance	Tutorial Assistance	Tutorial Assistance	

*Indicates classes by group.

THIS WEEK AT XAVIER

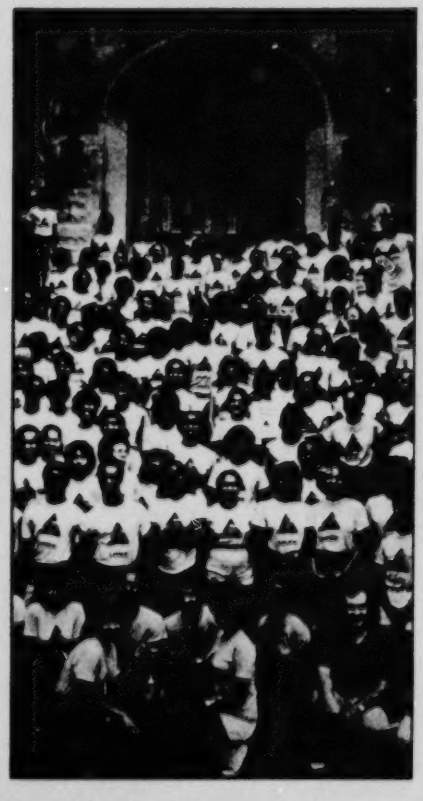
Special Report: Project SOAR

It's a bird! It's a plane. It's Project SOAR - - Xavier's special summer program for pre-freshman science majors, which is soaring to national prominence.

- - **SOAR participants show an overall increase in general intellectual ability upon completing the program.**
- - **SOAR participants with poor reading ability make an average two-year advance in both reading comprehension and vocabulary.**
- - **SOAR participants with low scores on scholastic aptitude tests average the equivalent of a 114-point increase on the SAT.**
- - **SOAR participants are four times more likely to complete their freshman year as a science major than freshmen who did not complete SOAR.**

The sciences at Xavier

In 1976 Xavier University of Louisiana had a full-time enrollment of 1612, with 26 percent of the students majoring in the natural sciences. That same year the Natural Science Division of Xavier, which has an 85 percent black enrollment, made a major new, cooperative effort to increase the University's potential for addressing the national problem of underrepresentation of blacks in the science-related fields.



Four years later it is obvious that the effort has been exceedingly successful. In the fall of 1980 Xavier's total enrollment stands at 2003, and more than 40% of these students are natural science majors. This increase in enrollment in the natural sciences has been accompanied by dramatic increases in placement of graduates in science-related fields. Over the past two years approximately 140 science students have been accepted into health professional schools or science graduate programs.

A major contributor to this success has been the very first cooperative endeavor undertaken - - the development of Project SOAR (Stress on Analytical Reasoning), a special six-week summer program for pre-freshman science majors by the Departments of Biology, Chemistry, Mathematics/Computer Science and Physics/Pre-Engineering, directed by JW Carmichael, Jacqueline Hunter, Lester Jones and Harold Vincent.

Project SOAR: an overview

Project SOAR is comprised of three components - - Piagetian-based laboratory experiments to improve general problem-solving skills, specific instruction to improve those analytical reasoning/reading skills needed on standardized exams and vocabulary building. Teachers in the program are a combination of regular science and mathematics faculty from Xavier, high school teachers and Xavier-educated medical and dental students.

Over the past four years 419 students have completed the SOAR program - - 57 in 1977, 109 in 1978, 113 in 1979 and 140 in 1980. Of this number, 390 were high school graduates who indicated a desire to enroll in a science the following fall, and 29 were 12th graders with similar interests. All of the latter participated in Summer 1980 in a special experimental portion of the program.

To provide the individual attention which is the corner stone of Xavier's success, each year the participants were divided into groups of approximately 25 students, and a medical or dental student was assigned as group leader/mentor/role model/parent image, etc. This group leader not only guided the SOAR students through the various components of the program, but also organized social activities and worked to motivate each student to maximum achievement.

Learning-by-doing promotes thinking

The first of three components of SOAR are 20 three-hour Piagetian-based laboratory exercises. Each is organized as a *learning cycle* containing exploration, invention and application phases. This organization is employed because studies indicate

WE'RE NUMBER ONE: Kelly King and Don Johnson, joined by fellow students during Summer 1980, assure the photographer that they're the tops in a SOAR competition. During the six-week program, Friday afternoons are given to group competition as motivational force.

that as many as 50 percent of college students in the U.S. cannot reason abstractly (at Piaget's formal level) in the manner needed for science or mathematics courses and that the learning cycle - - learning-by-doing - - actually promotes development of abstract learning. The original format was developed by Dr. Robert Karpus, dean, Graduate School of Education, University of California-Berkeley, based on his own experimental work with the theory of intellectual development postulated by Swiss epistemologist Jean Piaget.

Of the 20 such learning cycles used in SOAR, five each are from biology, chemistry, mathematics and physics. They have been developed by Xavier's faculty as units which stress five major components of problem-solving. These are abilities to (a) identify and control variables, (b) use proportional reasoning, (c) consider exhaustively all combinations of factors, (d) use probabilistic relationships and (e) recognize correlations between variables.

The laboratories are conducted by a combination of Xavier science/math faculty and high school teachers. The prevailing atmosphere within each classroom is one of cooperative group effort to solve a problem, with the teacher circulating throughout the room, continually asking questions which require students to verify, further test and devise additional experiments or further extend his/her knowledge. Great care is taken to avoid lecturing and to answering questions in a manner that always requires additional thought.

Intelligence *can be* taught

The second component of SOAR specifically attempts to teach the type of step-by-step logical reasoning needed to perform well on standardized aptitude exams. The teaching method used is the "cognitive skills approach" espoused by former Xavier faculty member Dr. Arthur Whimbey, author of the book, "Intelligence Can Be Taught," and "Teaching Sequential

IT'S A FIT: Arthel Neville gets some help in trying on the SOAR T-shirt from fellow SOAR student Conchetta White. Neville, who has since enrolled in pre-pharmacy at Xavier, also works as a model. You'll agree that White is pretty enough to model.

TIME TO THINK ABOUT TOMORROW: Assistant Pre-Health Advisor Linda Montegue discusses career plans with Andre Buck, Mobile high school graduate who has since enrolled at Xavier. Career counseling is made available to all students in the summer program.

I THINK WE'VE GOT IT: New Orleans area high school graduates Kim Dunn and Charles Valteau, enrolled in SOAR 1980 seem pleased with their lab work. The two are graduates of Xavier Prep and Brother Martin High School, respectively. (Photos by Huard)

Thought: The Cognitive-Skills Approach," *Phi Delta Kappan* (December 1977). The cognitive skills approach assumes that analytical reasoning is a skill of the same general sort as hitting a golf ball, swimming, etc., and that *it can be taught in the same manner*. This represents (a) demonstrating the skill in detail and then (b) requiring the student to practice while monitoring performance. This approach, while very common sense, has not been widely recognized previously, because thinking, unlike hitting a golf ball, takes place within one's head and cannot be easily monitored.

Further, the problem is compounded by our tendency to view "ability to work problems rapidly" as *good* problem-solving, when, in fact, good problem-solving is more accurately characterized by careful, slow analysis, with frequent checking for mistakes.

In SOAR, students are first introduced to the approach as a group by Xavier-educated medical or dental leaders serving as group leaders. They are then carefully monitored while paired as *problem-solver* and *listener* in practicing its use. Ninety minutes are devoted to this approach Monday through Thursday throughout five working weeks of the six-week program. Half of the time is spent on quantitative problems, and half is spent on verbal ones.

"Problem-Solving and Comprehension: A Short Course in Analytical Reasoning" (Whimbey and Lochhead, Franklin Institute Press, 1979) is used as the primary text for the first third of the program. A workbook, "Algebra - - An Introductory Course" (Bramscom, AMSCO Publications) is used in the quantitative portion, and selections from the ETS Graduate Record Examination Information Bulletin, the American Dental Association's Dental Admissions Test Perparation materials, etc. are used on the verbal section. All cognitive skills instruction is conducted by group leaders after training by and with supervision from Xavier faculty skilled in the approach.

Vocabulary-building: it can't be avoided

Since vocabulary is a prerequisite to good reading comprehension, a vocabulary-building component is built into SOAR as the third unit. Vocabulary-building drills are conducted for 30 minutes Monday through Thursday by group leaders.

Motivation by group competition

Since students are seldom enthusiastic about building reading or vocabulary skills, carefully controlled competition between the different groups is used as motivation. The competition consists of an hour-long written test, covering the previous week's work in both analytical reasoning (euphemism for cognitive skills training) and vocabulary and a short quiz bowl. All students are required to take the written exam on Thursday afternoon. The exams are graded overnight, and the scores for the various groups are tallied. The results are not announced until Friday afternoon after four students from each group have represented their group in the quick-answer quiz bowl.

At the conclusion of the quiz bowl, scores from the written tests and the quick answers of the quiz bowl are added and - - with great fanfare - - a special SOAR trophy is awarded for the week to the group with the highest score. Points are purposely scaled so that the performance of the group as a whole on the written test is a major factor in determining the winning group, with the quiz bowl serving merely to stimulate interest and generate spirit among the remaining members of the group, who act as a cheering section for their representatives on the four-member quiz bowl panel.

Efforts are purposely made to use the group spirit to facilitate the paired problem-solver/listener arrangement used in the cognitive therapy approach so that the students who score well willingly work with those who have done less well *for the good of the group*.

Project SOAR in more detail

Project SOAR has received national attention among educators as the result of having been featured, among a select number of interdisciplinary programs, in a series of reports on teaching in *Change* magazine in 1978 and by being included in an article on Piaget's legacy in American education in *The Chronicle of Higher Education*, Sept. 1980. Details of the program have also appeared in "Project SOAR (Stress on Analytical Reasoning): A Multidisciplinary Summer Program for Minority Science Students," *The American Biology Teacher*, March 1980, and "Teaching Critical Reading and Analytical Reasoning in Project SOAR," *Journal of Reading*, October 1980.

Related activities at Xavier University

The efforts initiated by the natural science departments with SOAR have spawned numerous academic year spinoffs. The obvious success of SOAR led to a follow-up mulitidisciplinary effort to modify entry-level courses in biology, chemistry, mathematics and physics to reduce attrition and increase level of performance. This effort has now been completed with similar success. Description of two parts of this endeavor may be found in "Cognitive Skills Oriented PSI in General Chemistry," *Journal of Developmental & Remedial Education*, Winter 1979, and "A Piagetian-Based General Chemistry Laboratory Program for Science Majors," *Journal of Chemical Education*, Sept. 1980.

Additional information about Project SOAR may be obtained from the following sources:

Overall: C. Eric Lincoln. "From Concrete to Abstract Reasoning: SOAR Plots the Course," 6th Report on Teaching, Change, August, 1978.

Piagetian-Based Laboratories:

JW Carmichael, Jr., Jacqueline Hunter, Lester W. Jones, Mary Ann Ryan, and Harold Vincent. "Project SOAR (Stress On Analytical Reasoning): A Multidisciplinary Summer Program for Minority Science Freshmen," The American Biology Teacher, Vol. 42, No. 3, 169 (March, 1980).

Analytical Reasoning/Reading Skills:

Arthur Whimbey, JW Carmichael, Lester W. Jones, Jacqueline Hunter, and Harold Vincent. "Teaching Critical Reading and Analytical Reasoning in Project SOAR," Journal of Reading, Vol. 24, No. 1, 5 (October, 1980).

Related Activities at Xavier:

JW Carmichael, Jr., Mary Ann Ryan, and Arthur Whimbey. "Cognitive Skills-Oriented PSI in General Chemistry for Improved Success of Educationally-Disadvantaged Students," Journal of Developmental and Remedial Education, Vol. 3, No. 2, 4 (Winter, 1979).

Mary Ann Ryan and JW Carmichael, Jr. "A Piagetian-Based General Chemistry Laboratory Sequence for Science Majors," Journal of Chemical Education, Vol. 57, No. 9, 642 (October, 1980).

JW Carmichael, Jr., et. al. General Chemistry Laboratory Manual (Piagetian-Based), Stipes Publishing, Champaign, IL, 1981.

GENERAL INSTRUCTIONS

2.1 All Personnel

SOAR is six weeks in length. It consists of one day of orientation, two days of pre-testing, five weeks of classes, and two days of post-testing. All faculty are expected to be available for seven weeks including a three-day orientation (the last day of which overlaps with the first day of student orientation), the six week period when students are on campus, and a two-day wrap-up immediately following the closing of the program. Assignments during the orientation, pre- and post-test periods, and the wrap-up will be detailed immediately before each begins. During the five weeks when students are in class, activities begin at 8:30 a.m. and continue through 3:30 p.m. daily. A typical weekly schedule is provided on page 5 of this manual. Responsibilities of the various faculty conducting each component of the program appear in later sections of this document.

2.2 XU and high school mathematics and science teachers

Your general responsibilities are to prepare for and conduct the Piagetian-based laboratory experiments which are contained in the SOAR notebook. Before beginning to do so, it is essential that you complete the Workshop on Science Teaching and the Development of Reasoning using a workbook of a similar name (available from the Lawrence Hall of Science, University of California, Berkeley). The workshop will be offered during the faculty orientation period.

It is generally expected that you will be available from 9:00 a.m. to 3:00 p.m. during the three-day faculty orientation period and the two-day wrap-up, from 9:00 -12:00 a.m. the remaining six weeks, and whatever additional hours (usually only a couple per week) are needed to prepare for the experiments. We would encourage you to get to know and to interact closely with the SOAR participants. In order to provide the opportunity for you to do so, we will provide you a FREE lunch in the student cafeteria during the six weeks the students are on campus.

2.3 Medical/dental student group leaders

You have been hired to work in SOAR because YOU ARE A SUCCESS (as demonstrated by the fact that you got into medical or dental school) and we believe that close association with roles models of similar age will help other students acquire/retain the motivation to obtain science-related careers also. Your general responsibility during the summer is to get to know each of the students in the group assigned to you (about 25) and to get them started out following in your SUCCESSFUL footsteps. (Isn't it miraculous how you have suddenly been transformed from a good-for-nothing-lazy-lout to a shining-example-which-others-should-emulate?)

Specifically, you should be working to make certain that every student in your group

a) remains in the program for the entire summer,

b) participates fully in the program,

c) improves his or her ability to reason analytically as much as natural ability permits,

d) chooses to major in a science (not necessarily that which you chose),

and e) enrolls at Xavier.

One of the sessions during the orientation period will be devoted to a discussion of your role in each of these areas and how you may function most effectively in each. Generally, you should rely more on praise, getting to know the student, expressing interest, and other kinds of encouragement than on threats of grades since (although grades will be given) SOAR carries no academic credit.

Students applying to SOAR were assigned to groups so as to mix local/non-local, high ability/low ability, male/female students as much as possible. In addition, an effort was made to separate students from a given high school since establishing contact with a variety of persons entering the University is likely to help them make it through. For all practical purposes, it is not possible for a student to transfer to another group (only the director can approve such transfers). If you should find that you have personality clashes with individuals in your group, you should deal with it (without discouraging the student) if possible. It is generally expected that you, a succcessful XU graduate who expects to enter a profession in which you will deal with people daily, can handle such problems. If not, please consult with the director of the program. UNDER NO CIRCUMSTANCES SHOULD YOU ENGAGE IN ANY ACTIVITIES WHICH WOULD BE UNPROFESSIONAL IN NATURE.

Students in your group will represent a wide range of ability and interests. It is your duty to keep as many as possible of them in the program. In order to encourage you to do so, students who drop out will continue to be counted in your group (in computing scores in the competitions) until such time as the director is personally convinced that you have exhausted all possible means of retaining the student--i.e. don't even bother to try. In working with your group, you should actively encourage individuals within the group to assist each other (with particular attention to getting good students to work with poorer ones--without hurting anyone's feelings) and to compete against the other groups.

It is generally expected that you will be on-campus from 8:30 a.m. through 4:00 p.m. Monday through Friday for the entire seven week period. Your schedule during orientation, pre- and post-testing, and wrap-up will be made available shortly before you begin each. During the five weeks when participants are in class, you are normally expected to complete the following during the time indicated.

8:30 (Monday only)	Submit summary sheet for your group's performance the previous week using forms available from the director
8:30- 9:00	Work with those students from your group who need assistance with emphasis on those who did poorly on the previous Friday's competition
9:00- 9:15	Go to class with your students, take roll, get everybody working, etc.
9:15- 9:30	Contact any student who was not present when you took roll. Telephone city students, check the dorm for others.
9:30	Record absences for your group on the master roll in the director's office.
9:30-10:00	Grade laboratory reports/papers, return papers, etc.
10:00-10:30	Meet with coordinators of analytical reasoning, problem-solving, and vocabulary-building.
10:30-11:00	Grade papers and/or prepare for afternoon.
11:00-11:50	Return to your group. Check with the instructor and circulate to make certain that all are progressing satisfactorily. As they complete the experiment get them started playing Mastermind, playing Scrabble, studying for the afternoon, etc. It is your responsibility to make certains the needed materials are transported from the director's office to the classroom.

11:50-12:00	Collect each student's laboratory report and allow them to go to lunch. UNDER NO CIRCUMSTANCES MAY THEY LEAVE EARLIER THAN 11:50.
12:00- 1:00	Have a FREE lunch with the students. Remember, one of your jobs is to get to know them well.
1:00- 1:45	Conduct the analytical reasoning exercises specified for the day. Attempt to generate interest by referring to the upcoming competition and/or using group activities. Collect the indicated paperwork before proceeding.
1:45- 2:30	Conduct the problem-solving activities for the day in a manner similar to that used above. Remember to collect the paperwork for the day.
2:30- 3:00	Conduct the vocabulary-building exercises for the day remembering to collect the specified homework.
3:00- 3:30	Provide tutorial assistance for those in your group who need it.
3:30- 4:00	Catch your breath (and interact on an informal basis with the students) before going home.
5:00	GO TO BED AND GET LOTS OF REST, YOU'RE GOING TO NEED IT FOR TOMORROW.

Some additional points which are of value are

...There will almost always be something written to be collected in each class. You should grade the materials and keep a record for the weekly summary which is due at 8:30 on Monday.

...All papers should be returned to the students after grading and after all groups have completed them. This means laboratory reports must sometimes be kept for a week.

...All materials which you are expected to need are already in the notebooks given to the students or are available in the director's office. The latter include sample tests for each section in the vocabulary book. If you need additional materials, contact the director.

...PROBLEM-SOLVING AND COMPREHENSION BOOKS MAY NOT BE REMOVED FROM THE CLASSROOMS--I.E. MAY NOT BE TAKEN HOME BY STUDENTS.

INSTRUCTIONS FOR PIAGETIAN-BASED LABORATORY EXPERIMENTS

3.1 General

Instructors must complete the Workshop for Science Teaching and the Development of Reasoning* before beginning teaching the Piagetian-based laboratory experiments. In that workshop you will learn that the learning cycle is one format for teaching to promote the development of reasoning skills. Each of the 20 laboratory experiments in SOAR are organized as a learning cycle. These experiments (five each from Biology, Chemistry, Mathematics, and Physics) have been developed to stress five major components of good problem-solving (Piaget's formal operational level of cognitive development). The five are: control of variables, proportional reasoning, combinatorial reasoning, probability, and recognizing correlations between variables. A list of the experiments and the component which they stress is given below:

Control of Variables

Biology	Factors Affecting the Breathing Rate of Goldfish
Chemistry	Rates of Chemical Reactions.
Mathematics	Relative Sizes of Fractions
Physics	Periodic Motion for Fun & Profit

Proportional Reasoning

Biology	Geologic Time
Chemistry	The Burning of Magnesium in Air
Mathematics	Classification of Plane Figures with Three Sides
Physics	Forces that Move Objects

Combinatorial Reasoning

Biology	Can Pillbugs Live on Photomeda?
Chemistry	The Case of the Missing Labels
Mathematics	Counting Without Using Fingers or Toes
Physics	Switch Combinations

Probability

Biology	Tongue-Rolling & Probability
Chemistry	Simulated Isotope Dilution
Mathematics	Take Your Chances
Physics	Dice-Atoms Radioactivity Analog

*Using materials by the same name available from the Lawrence Hall of Science, University of California, Berkeley, California 94720.

Recognizing Correlations

Biology	The Case of the Missing Flagella
Chemistry	Shaking the Blues, Chemistry-Style
Mathematics	Making Predictions with Graphs
Physics	Electrical Circuits That Don't Shock

Each of the laboratory exercises is three hours in length. The four which stress one component of problem-solving form a unit which, when combined with one day of computer programming, is a week's work. Students should not be told that the exercises stress particular processes, but the last day of each set of four should conclude with a short rap session in which students are asked to seek common elements in what they have done for the past five class days (exclusive of the computer programming). The experiments within a given set of four are designed so that the order in which they are completed is unimportant. This makes it possible to divide SOAR participants into five subgroups which complete one experiment or computer programming each day of the week. Each module is numbered internally on the upper right-hand corner of the page as well as consecutively for the entire notebook at the bottom center of each page. The internal module number (on the top) is preceded by a code which indicates the discipline and the component of problem-solving. For example, the code "BCR" refers to "Biology" and "Correlational Reasoning."

While conducting the problem-solving laboratories, it is important for instructors to remember that the experiments are not designed to impart specific content but rather to provide the student the opportunity to think through and analyze a given situation. Therefore, we are not seeking "correct" answers but rather encouraging students to arrive at logical conclusions. In attempting to accomplish this, it is important that questions not be answered directly but rather that the instructor become proficient at asking questions which promote thinking (no matter how much it hurts). Below are some suggested responses which tend to do this.

How do you know that?

Are you sure?

What can you do to convince ... that this is true?

How do you know that "so and so" isn't involved?

What relationship can you see? (i.e. Don't worry about what anyone else said, what do you see?)

What do you know now?

Now that you have seen ... , how does this help you with ... ?

Group interaction is DEFINITELY IN!!! Direct copying without thinking is DEFINITELY OUT!!!

In addition, don't forget that SOAR participants are potentially new freshmen at Xavier and that the entire process of learning to think more analytically may sometimes be frustrating. Therefore, always be friendly, encouraging, and alert for those instances when a student becomes upset because you don't give a direct, definite answer. The best approach to handling such instances is to remind the student of the purpose of the program--to develop thinking skills--and then proceed to try to get the student involved in the same way they might do in a complicated game. It helps to tell them that the program will help when they get to the entry-level science and mathematics courses at Xavier--mentioning specific instances from the general chemistry laboratory program.

At the end of each laboratory period, the group leader should collect a completed laboratory report from each student. The reports should be graded, grades should be recorded in the record book provided, a summary of the grades should be submitted each Monday morning (on the form in Appendix I), and laboratory reports (with grades clearly marked on each) should be returned to the students as soon as all groups have completed a particular set of experiments. Reports should be graded on a numerical scale. There will be a general meeting at the beginning of the program during which time the rules for grading will be jointly determined by the group leaders. Periodic discussion of grading during the morning sessions will ensure that a uniform system is used throughout the program.

There is no academic credit for participating in SOAR. Therefore, the only reward for doing well are the gold metals which are awarded at the conclusion of the program. Do not directly lie to the students concerning the lack of penalty for not doing well but, on the other hand, don't go out of your way to given them any details--i.e., if you can keep them thinking that there are "course grades" and that the grades you are assigning contribute to them, go ahead and do so being careful to remain truthful.

Group leaders should be prompt in taking roll, contacting absent or tardy students, and reporting absences to the director as outlined on the schedule on pages 9-10. If students in your group are repeatedly tardy or absent, you should talk with the student and try to resolve the problem. Do not hesitate to use peer-pressure from the other students in the group to assist you (within limits) since tardiness and absences are likely to be connected to poor performance in the competitions and consequently to hurt the entire group.

Students who complete the laboratory experiment before the end of the three-hour period (before 11:50) should be directed by the group leaders to play Mastermind, to play Scrabble, or to work on homework for the afternoon sessions. Under no circumstances may a student leave the laboratory before 11:50.

The following sections contain specific comments concerning each of the twenty laboratory experiments.

3.2a Biology: General

Each of the five biology experiments in SOAR was developed to stress one of the five components of problem-solving included in the program. The content of each was selected on the basis of anticipated student interested with little or no attempt made to provide content needed in regular biology courses.

The majority of the materials needed for the experiments are available in any biology laboratory. The remainder are readily obtained from variety stores or school supply houses.

3.2b Biology: Control of Variables

Name of Experiment:

Factors Affecting the Breathing Rate of Goldfish

General Description:

Students work in pairs to study the rate at which a goldfish moves its opercula under various conditions as a means of learning that valid experiments must be designed so as to control variables which are not under investigation.

Materials Needed:

Per Set of Students

1 timing device with second hand (wall clock is suitable)
1 large beaker (about 400 ml) of fresh aquarium water
1 cover for beaker
1 thermometer
1 goldfish (which hopefully will survive to be used another day)
1 beaker of aquarium water in which oxygen concentration has been reduced (by boiling and cooling just before use)
2 sheets of graph paper (1/student)

For the Group

1 beaker of hot aquarium water to be used in raising the temperature of the other water up to 35°C--NO TO INSERT FISH IN DIRECTLY
crushed ice to be used in cooling water
soda siphon to be used in pumping carbon dioxide into water

Comments on Exploration:

Allow the student almost complete freedom to explore the possibilities after a very brief introduction. "Aquarium water" is water which has been dechlorinated by allowing to sit for at least 24 hours before using.

Comments on Invention:

Have the students discuss which environments increase the breathing rate of the fish and which decrease it. Use the chalkboard to collect results.

Comments on Application:

While students are investigating the effect of temperature on the breathing rate, circulate to each desk with soda siphon in hand and ask if they will allow you to squirt some carbon dioxide into their beaker. Question any response. Try to get students to recognize, and state explicitly, that doing so will invalidate the experiment since it will introduce an uncontrolled variable. Don't worry about the choice of words--just the idea.

3.2c Biology: Proportional Reasoning

Name of Experiment:

Geologic Time

General Description:

Students work in pairs to develop a representation of a geological time chart on which different colored areas accurately reflect the relative length of time of each geological period.

Materials Needed:

Per Set of Students

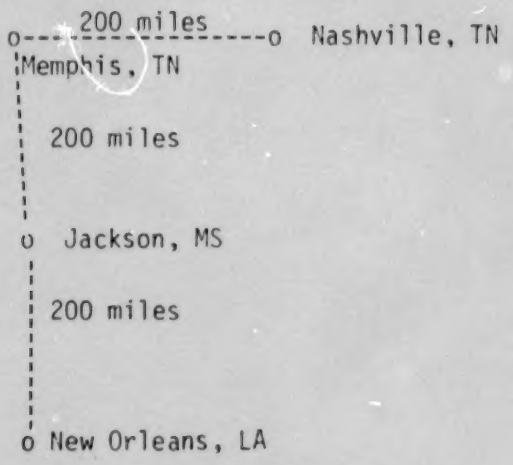
1 "board" approximately 3" wide, ½" thick, and 30" in length (No two pairs of students should have boards with the exact same length. A variation of 1" is sufficiently different to ensure that each pair must work independently. "Boards" do not necessarily need to be wooden. Less expensive styrofoan sheet may easily be cut into pieces which are suitable.)
1 meter stick
1 calculator (not absolutely necessary, but very handy--it may be shared with other pairs)

For the Group

A minimum of five different colored paints (and brushes) which may be used to color the various time periods on the "boards" designed by each pair.

Comments on Exploration:

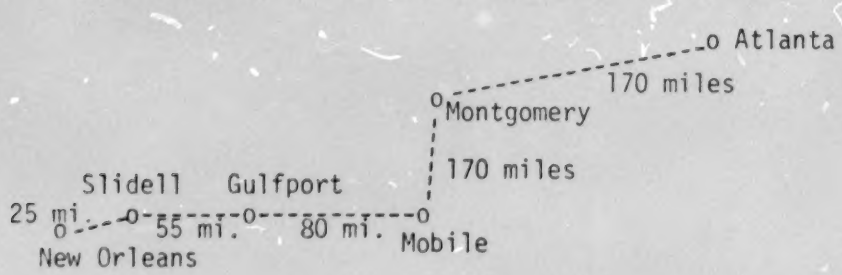
At the beginning of the experiment, the following diagram is placed on the chalkboard:



Comments on Exploration (continued):

One of the boards to be used in this exercise is then displayed to the class and the students are told that this board represents the distance from New Orleans to Nashville. They are then asked where a line representing Jackson would appear. When an answer is forthcoming, the responder is asked to explain how he or she arrived at the answer. Subsequent questioning gradually leads to a step-by-step procedure to be used for determining the position of the mark. This procedure is written, as developed, on the chalkboard.

The following diagram is then drawn on the chalkboard



and the class is asked, if the board now represents the distance from New Orleans to Atlanta, where would the mark for Slidell appear? After answers are collected and discussed, the class collectively checks to see if this answer could have been obtained using the procedure developed in the first example. In so doing, the general applicability of the procedure is tested. The class is then instructed to begin the activity.

Comments on Invention:

Instructors circulate through the room checking to make certain that each student is proceeding satisfactorily. When difficulties are spotted, the instructor should initiate reconsideration of the introductory example trying to get the student to show how the proportions were obtained there. It should then be possible to return to the present problem and provide guidance (but not direct answers) which will allow the student to locate and resolve the difficulty.

Comments on Application:

This is merely more of the same type of activity as in the "invention", the instructor should proceed in the same manner.

3.2d Biology: Combinatorics

Name of Experiment:

Can Pillbugs Live on Photomeda?

General Description:

Students work in pairs to determine under what environmental conditions are pillbugs able to survive. It is possible for them to lower total pressure, increase concentration of carbon dioxide, lower temperature, or any combination of these.

Materials Needed:

Per Set of Students

7 250-ml Erlenmeyer flasks
3 solid rubber stoppers which fit the flasks well
4 one-hole rubber stoppers which fit the flasks well*
4 "L-shaped" pieces of glass tubing which fit snugly into the rubber stopper*
4 short pieces of rubber tubing which fits both the glass tubing and the fitting to the vacuum pump*
4 clamps which may be used to close off the rubber tubing
1 pair of forceps
7 pieces of filter paper about the same size as the bottom of the flasks
28 pillbugs (minimum, may be collected in yards in New Orleans)
7 labels for the flasks

*CAUTION: It is strongly advised that the instructor assemble the stopper/glass tubing/rubber tubing in advance to minimize danger of students' inflicting injury on themselves. Glycerine is a good lubricant when doing so. The total assembly (including clamp) must be tight if it is to serve its purpose of maintaining low pressure in the flask.

For the Group

A vacuum pump with a guage attached
A carbon dioxide dispenser
1 thermometer (to be placed in the refrigerator)

Comments on Exploration:

There are seven different combinations of environmental conditions possible (in addition to the control, normal conditions on Earth). There are purposely more spaces in the notebook than different sets of conditions. With a little questioning, the students will arrive at all seven and will decide that there are no other possibilities. The instructor should check to make certain that each pair has written down each set in a coherent manner and that each can justify why they have exactly seven. When all pairs have completed the chart of combinations, one student should be asked to place his or her results on the chalkboard. At that time, a short discussion concerning whether or not other combinations are possible is appropriate.

After completing the systematic consideration of all possible combinations of conditions, the students should then set up a flask corresponding to each. This is accomplished by placing (a minimum of) 4 pillbugs, a moistened piece of filter paper, a stopper (using both one-holed and solid ones), and an appropriate label on each. The filter paper should be folded in fourths before insertion in order to make it easier to place in the flask and to provide a moist atmosphere without unduly hiding the pillbugs. The label should state explicitly the combination of conditions to which pillbugs in it will be subjected--not just a number. The stoppers with tube attachments should be placed on the flasks which will be subjected to lowered pressure.

The students should then create the atmospheric conditions listed on each flask as indicated below:

Increasing concentration of carbon dioxide

Use a carbon dioxide dispenser to place three short bursts of carbon dioxide into an open flask. Then close the flask with a stopper. Carbon dioxide cartridges may be purchased at many establishments selling alcoholic beverages. Martin's Wine Cellar in New Orleans is recommended since it also has a good delicatessen (and free samples of wine) on which one may graze while waiting.

Reducing total pressure

Attach the rubber tubing from a flask to a vacuum pump and evacuate until the guage reads about 40 cm (15 inches) of mercury. Then tightly close the clamp on the rubber tubing. Note: All components must fit together tightly if the container is to retain low pressure.

Decreasing temperature

Place the stoppered flasks in a refrigerator, leave overnight, and observe behavior of pillbugs one hour after removal. A thermometer should be placed in the refrigerator for use by the entire group.

Comments on Invention:

Once a pair has set up the seven flasks, the instructor should produce a set of seven, identical to the ones they have set up, "from the previous day." This seven, not those the pair set up, is to be used in invention. The instructor should explain to each pair (or the group if they are ready to begin at the same approximate time) that this is being done only to make it possible for the class to complete the activies in one three-hour period. It should be stressed that these flasks were from the previous class and that their flasks will be used by tomorrow's class. As noted previously, the flasks removed from the refrigerator should be allowed to stand at room temperature for one hour before making observations. Obviously, it is necessary for the instructor to prepare a complete set of seven flasks for each pair of students in the first group to complete the exercise.

Comments on Application:

As students complete the application, check their papers to make certain that all possible combinations have been considered. If some are missing, the student should be guided to discover this by questioning and then sent back to complete the experiment.

3.2e Biology: Probability

Name of Experiment:

Tongue Rolling and Probability

General Description:

Students work in pairs to produce genetic combinations which produce various types of inherited traits using knives, forks, and spoons as chromosomes and beads as genes.

Materials Needed:

Per Set of Students

- 4 knives, 2 white and 2 black
- 4 forks, 2 white and 2 black
- 4 spoons, 2 white and 2 black
- 4 paper plates
- 4 beads, 2 blue and 2 white, which fit on the tines of the forks (dyed macaroni is appropriate)
- 12 corn seeds (offspring of Gf cross, G = green, g = albino)
- 1 container and soil for planting seeds

For the Group

Nothing extra

Comments on Exploration:

Begin with a very short overview which explains that the traits which one inherits are determined by probability. The mechanism by which this occurs is first meiosis to produce sperm or eggs and then fertilization to produce offspring. This experiment provides the opportunity to investigate the probability relationships in both and thus to determine the chances of passing on a particular characteristic.

First the students must understant the process of meiosis. Begin by explaining the process on the chalkboard with separate diagrams for replication, synapsis, metaphase I, separation of homologs, cytokinesis I, metaphase II, anaphase II, and cytokinesis II. Tell the students that pairs of knives, forks, and spoons (one black and one white) represents pairs of chromosomes and that paper plates represent cells. Beginning with three pairs of chromosomes (2 knives, 2 forks, and 2 spoons--one of each color) on a paper plate, the students should then simulate the meiotic process. The additional knives, forks, and spoons will be needed during replication and the additional plates during cytokinesis. The instructor should circulate and make certain that each pair is able to perform this simulation before proceeding.

When the entire class understands the process of meiosis and what happens to chromosomes as it occurs, they should be told that "genes" located on the chromosomes actually carry the various inheritable traits. There are two genes (minimum) for a trait and these are located on homologs. The students should be given definitions of homozygote, heterozygote, dominant gene, recessive gene, phenotype and genotype. The first gene to be considered in this experiment is that for the ability to roll one's tongue. Poll the class to see who can and who can't do so. Then tell the students that, for the purpose of this experiment, the gene for tongue-rolling, a dominant gene, will be represented by a blue bead and that for non-tongue rolling, a recessive gene, will be represented by a white one. Give each pair of students four genes, two blue and two white, and tell each to place a white bead on the tines of one fork and a blue bead on the tines of the other fork. The extra beads are to be used for replication.

Each pair of students should now be designated as "male" or "female" with equal numbers of each in the class if possible. Those who are "male" are given white chromosomes. The "females" are given black chromosomes. Each pair of students should now re-assemble the original one cell with three different pairs of chromosomes (a plate with pairs of different-colored knives, forks, and spoons. Each pair should now repeat the entire process of meiosis to produce "sperm" or "eggs." Once again, the additional plates, knives, forks, and spoons will be needed at various stages of the process. At the end, each pair should answer the questions in the exploration.

Comments on Invention:

Invention should begin by pairing student-pairs designated as "female" with those designated as "male." The two pairs of students should then proceed to combine their "sperm" and "eggs" to determine the various kinds of offspring which are possible. All possible combinations should be recorded in the notebook. After all have completed the combination process, one group should be asked to place their results on the chalkboard and to indicate how the results were obtained. After the entire class has had a chance to discuss the combinations and reach a concensus that it is correct, call their attention to the fact that one homolog in the offspring comes from the mother and one from the father. Then discuss the concept of probability.

At this time give the students a different trait to be represented by the two beads. Have each student figure out what kinds of games can be produced if both parents are heterozygous for the trait. If necessary, make them repeat the meiotic process to find the possible gametes.

Comments on Application:

Allow students to complete the application section without repeating the meiosis and fertilization unless they run into problems. When difficulties arise, they should be advised to return to the model to obtain an answer.

The product rule of probability theory states that the frequency with which two or more independent events occur together is equal to the product of the frequencies with which each event occurs individually.

For example, if tongue-rolling (T) is dominant over non-tongue-rolling (t) and six-fingers (S) is dominant over five (s), then a TtSs x TtSs cross is obtained by:

1st considering a Tt x Tt cross which yields 3/4 T : 1/4 t

2nd considering a Ss x Ss cross which yields 3/4 S : 1/4 s

3rd 3/4 T : 1/4 t x 3/4 S : 1/4 s which yields 9/16 TS : 3/16 tS : 3/16 Ts : 1/16 ts

The final activity in exploration, planting corn seeds, both reminds the students that the concepts studied in this experiment are widely applicable and provides materials for use in the next week's work.

3.2f Biology: Correlational Reasoning

Name of Experiment:

The Case of the Missing Flagella

General Description:

Students work in groups of four to determine if a population of living things have been affected by various factors.

Materials Needed:

Per Set of Students

A calculator

For the Group (of 24)

-Euglena Culture I, a large paper bag containing

210 Euglena with flagella
120 Euglena without flagella
15 Euglena-fission with 2 flagella
30 Euglena-fission with 1 flagellum

made by ditto using the models in the SOAR notebook

-Euglena Culture II, a large paper bag containing

450 Euglena with flagella
15 Euglena without flagella
35 Euglena-fission with 2 flagella
0 Euglena-fission with 1 flagellum

made by ditto using the models in the SOAR notebook

-Rat Cage A, a large paper bag containing

120 fat rats
80 skinny rats

made by ditto using the instructor's imagination

-Rat Cage B, a large paper bag containing

180 skinny rats
20 fat rats

made by ditto

Comments on Exploration:

The instructor should initiate the idea of correlation, as opposed to a direct relationship, by the following. First, make up and put on the chalkboard some data which illustrates the observations by sociologists that the proportion of XXY (rather than XY) males in prison populaces is considerably higher than in normal society. Then ask the students to analyze this data. With a little questioning, they should arrive at the idea that while it is not true that all XXY males are criminal, there is some kind of strong correlation between XXY males and criminal activity.

Second, general similar data concerning cigarette smokers and lung cancer. Again, a group analysis should establish that there is a relationship, albeit not one for one, with smoking and the presence of lung cancer.

After the two initial discussions (no more than 20 minutes total), introduce the present problem via the initial portion of the exploration. Upon guiding the class to note the absence of flagella on some Euglena taken from Bottle I after the hormone was introduced, divide the class into halves (working as groups of four), and assign each a particular culture to investigate. At this time, they should be told that the data they collect will be combined for the analysis and appropriate tables should be placed on the chalkboard. Each student should then be told to withdraw a sample of ten organisms from the assigned culture, to count the number of each kind of Euglena in the "sample," to record the data in his or her notebook, and to place it in the appropriate space on the chalkboard. Data from other individuals should be copied into the notebook as it appears on the chalkboard.

Comments on Invention:

The entire class should discuss the data obtained attempting to reach some general concensus concerning the first two questions in invention. During the discussion, the instructor should strive to get the class to

a) conclude that there is no direct relationship between absence of flagella and hormone (since all organisms from Bottle I are not missing flagella) but that the probability of finding a Euglenae without a flagellum is greater in Bottle I than in Bottle II so there is some sort of correlation.

and b) recognize that combining data from the various samples from a given sample (either by taking totals or averages) gives a more reliable answer than could be obtained from any one sample.

After some concensus is reached, students should return the Euglena to the bags and perform the second experiment taking either 13 organisms from Bottle I or 19 from Bottle II. This data should be tabulated in the notebook and on the chalkboard in the same manner as was the first. When all is collected, again initiate a group discussion to see if this data substantiates the previous conclusion. With some questioning, the group can be lead to realize that collecting unequal numbers in the samples has complicated the comparison and that discarding some data isn't appropriate. At this point, it is appropriate to introduce the concept of chi-squared as a way of a) taking into account different sample sizes and b) providing some measure of "how strong" a correlation is. Each group of four students should calculate chi-squared for both of the sets of data--USING CALCULATORS IF YOU WANT TO REMAIN SANE. They should use the data from Bottle II for expected frequencies.

Invention should be concluded by briefly explaining chi-squared tables and allowing the students to use one to determine the probability (roughly) that the correlation is statistically significant.

Comments on Application:

As students complete the invention, they should be directed to application. Each student (in the group of four working together) should take a sample of at least ten rats from each cage, replacing them after they count the sample. (Remind them to shake the cage before each sampling.) Each group of four should complete the application separately.

Comments on Completing the Application from Last Week

As noted in the previous Biology experiment, this portion of the experiment provides a) a chance for the students to see that inherited genetics actually involve probability and b) to see how chi-squared can be used in another situation. The corn seeds are offspring of a Gg x Gg cross (G = Green and g = Albino). Students should first write down their own observations about the plants including the numbers of each phenotype. They should then determine theoretically what phenotypic ratios should have been obtained from a Gg cross and discuss why empirical and theorical ratios are not the same. In so doing, it is likely that they will decide that a larger set of data would be helpful in verifying the theoretical ratios in which case they are free to observe the plantings by other students. Eventually, they should use chi-squared to support their conclusions.

If corn plants are not available, use prepared data. A chi-squared table is included on the following page.

Values of Chi-Squared

df	Probabilities										
	.99	.95	.90	.80	.70	.50	.30	.20	.10	.05	.01
1	.0002	.0039	.0158	.0642	.148	.455	1.074	1.642	2.706	3.841	6.635
2	.0201	.103	.211	.446	.713	1.386	2.408	3.219	4.605	5.991	9.210
3	.115	.352	.584	1.005	1.424	2.366	3.665	4.624	6.251	7.815	11.345
4	.297	.711	1.064	1.649	2.195	3.357	4.878	5.989	7.779	9.488	13.277
5	.554	1.145	1.610	2.343	3.000	4.351	6.064	7.289	9.236	11.070	15.086

3.3a Chemistry: General

The chemistry experiments in SOAR were developed to stress the five components of problem-solving chosen to be included in the program. Content was selected solely on the basis of doing this and, hopefully, generating student interest.

The chemicals, glassware, and equipment needed for the chemistry experiments in SOAR are readily available in any general chemistry laboratory. The amount of each has been kept to a minimum. Therefore, there is no need for students to have their own laboratory desks. Instead, sufficient equipment for a given experiment is to be distributed to students at the beginning of each period and collected, for reuse, at the end.

It should be assumed that SOAR participants have had no previous exposure to the chemistry laboratory. Therefore, time should be spent at the beginning of each laboratory period stressing the need for safety. Students should be specifically told the following:

1) Horse-play is not allowed in the laboratory. Failure to observe this rule will result in automatic expulsion from the program.

2) All faculty and students must wear eye protection (either glasses or goggles) while in the laboratory. Students who do not normally wear glasses may pick up a pair of goggles each day as they enter the room and return them as they exit. CONTACTS DO NOT SUBSTITUTE FOR EITHER.

3) The location of the fire extinguisher in the room and how to use it.

4) The location of the exit routes from the room.

5) The location of the shower, the location of the eye-washes, and the use of both.

Finally, it will be necessary to demonstrate a number of common laboratory operations (such as using balances) to the students as the program progresses. Please supervise them closely during the time when they are first learning to use the equipment.

3.3b Chemistry: Control of Variables

Name of Experiment:

Rates of Chemical Reactions

General Description:

Students work in pairs to investigate the relationship between the rate at which a chemical reaction occurs and the initial concentrations of solutions which are reacting. The reaction is a typical "iodine clock" reaction for which details may be found in a number of general chemistry laboratory texts.

Materials Needed:

Per Set of Students

1 ten-ml graduated cylinder
1 100-ml graduated cylinder
1 250-ml Erlenmeyer flask
500 ml of KIO_3 solution distributed approximately equally among solutions with concentrations of 1, 2, 3, & 4 grams/liter
500 ml of $NaHSO_3$ solution distributed approximately equally among solutions with concentrations of 1, 2, 3, & 4 grams/liter
75 ml of starch solution (freshly-made) distributed equally between solutions with concentrations of 1 and 2 grams/100 ml
1 watch with a second hand, have stop watches available if needed

For the Group

-Sufficient pairs of eye goggles to ensure that all students and faculty have eye protection in the laboratory.
-It is easier to prepare stock solutions to be shared by the entire group than for each pair of students. All except the starch solution may be made up well in advance. The starch solution should be made up daily just before use.

Comments on Exploration:

It should be assumed that students entering the laboratory have no prior exposure to chemistry laboratories. Therefore, spend some time each period discussing safety. It is especially important that this be done well at this, the first of the chemistry laboratory periods. Specific items to be covered were discussed in the "general" section for chemistry.

Additional laboratory techniques which should be demonstrated/stated are:

1) Use graduated cylinders for measuring volume.

2) Do not pour reagents back into the stock bottle.

3) Rinse glassware well between different experiments.

4) BE CAREFUL WHEN SWIRLING (OR STIRRING) TO MIX SOLUTIONS.

In initiating the actual experiment, allow the students to complete the exploration in pairs. Then tell them that the general purpose of the experiment is to determine if the amount of time required for the blue color to appear is affected by the concentrations of the various solutions added. It is not necessary to get into a detailed discussion of concentration, but some general comments may be necessary. As the students begin the experiment, be sure to circulate around the room getting all started in the right direction.

Comments on Invention:

After and hour and forty-five minutes (at 10:45 normally), stop the experimentation and get the class together for a group discussion of results. Ask whether or not they found concentrion of KIO_3 to have any effect. If yes, ask someone to explain how they could tell and to put the data which supports the statement on the chalkboard. Ask if others have similar data. Make certain the ensuing discussion makes clear that it is possible to tell that KIO_3 affect rate only if the concentrations of the other substances were held constant.

Conduct similar discussions concerning the effect of the concentrations of $NaHSO_3$ and starch. Then direct the students to the Application section. Either the effect of temperature or of light may be considered there.

This experiment generally gives good results. Occasionally, however, it does not. Such failures can usually be corrected (if noted in time) by making up fresh solutions. It might be wise to check the starch solution first since it must be fresh to work. If the data collected is poor, don't worry about getting additional that laboratory period. Just keep in mind that the purpose of the experiment is to lead the student to recognize the necessity of controlling variables when attempting to determine if concentration affects reaction rate. This principle can be elucidated no matter what kind of patterns are shown by the data. Remember, SOAR attempts to stress process first and content second.

Comments on Application:

If time permits, the students may be gathered into a group at the end of the period to discuss their results--once again with emphasis on the necessity to control variables in order to make valid statements. Remember to collect the goggles at the end of the period AND MAKE THE STUDENTS CLEAN UP THEIR DESK AREA.

3.3c Chemistry: Proportional Reasoning

Name of Experiment:

The Burning of Magnesium in Air

General Description:

Students, working in pairs, burn magnesium, obtain the weight of the product, combine that data with similar data furnished by the instructor, and then seek to analyze that data. The purpose is to determine what (if any) relationship exists between the weight of the reactant and product.

Materials Needed:

Per Set of Students

1 sheet of graph paper/student
1 sample of magnesium ribbon of approximately 0.3 gram mass (Putting each in a separate envelope makes it easy to distribute them.)
1 crucible
1 crucible cover
1 crucible tongs
1 clay triangle
1 Bunsen burner
1 ring stand and ring (on which the triangle will fit)
1 small, transparent metric ruler

For the Group

-balances which will weigh to the nearest 0.01 g
-sufficent goggles to ensure that all have eye protection

Comments on Exploration:

Reiterate the safety precautions in the general section for chemistry and make certain that all students and faculty are wearing eye protection.

This may be the students' first introduction to the use of a balance. Therefore, take them two at a time (partners) and show them how to use one of those available. Weigh the crucible for them as you demonstrate. Then have the pair weigh the crucible plus magnesium sample while you watch (without cringing).

While some students are using the balances, others should be setting up the ring stand, triangle, and crucible. A sample apparatus should be set up in the front of the laboratory to show them how to do it. The students should be told that when they have weighed the magnesium and assembled the apparatus, that they should request an instructor to ignite the magnesium and get the reaction started. Ignition is accomplished by breaking off a small piece of the ribbon from the weighed sample, holding it with tongs over the crucible, lighting it with the Bunsen burner, and then dropping it quickly into the remainder of the magnesium sample. If the entire sample does not begin to burn, the process should be repeated. When the whole sample is ignited, tell the students to continue heating the crucible strongly for five minutes, to allow it to cool for at least five minutes, and then to re-weigh it. All weights should be recorded in the appropriate place in the notebook.

The instructor should continually stress the need to wear eye protection. Many students who are not used to wearing glasses tend to remove them when they want to see well--like during the ignition when they need them the most.

Note: Simply heating magnesium in the crucible is unlikely to suffice since it is difficult to reach ignition temperature with direct flame.

As the pairs of students complete the exploration, tell them that time does not permit them to collect the additional data which they will need for a good analysis. However, other data have already been collected for them, by the exact same procedure they just used, and the results are in the data table in the notebook. Each pair is to list their data on the sheet as sample #1 and then use the entire set of data to answer the questions in the invention part of the experiment.

Comments on Invention:

Students will need assistance in setting up the graph. Tell them it must have a title, that axes must be labelled, that units on a given axis must be equal, that the variable mentioned first should go on the x-axis, etc. Then allow them to fumble their way through to the last question with instructors circulating and asking questions which provide guidance. When most students are ready for the last question, it might be well to get the class together, display a graph or two on the overhead projector allowing the class to pick out mistakes, and then briefly outline the procedure for obtaining the slope and intercept of a straight line. The latter should be summarized on the chalkboard for easy reference as needed. All graphs should be checked by the instructor before the pairs proceed to application.

Comments on Application

Circulate making certain that the students are able to use both the graph and the equation in answering the questions.

Collect goggles and get the students to clean up at the end of the period.

3.3d Chemistry: Combinatorics

Name of Experiment:

The Case of the Missing Labels

General Description:

Pairs of students attempt to identify solutions whose labels are missing by comparing reactions between these solutions with those between a similar set which are labelled.

Materials Needed:

Per Set of Students

1 spot plate or 12 test tubes and a holder
100 ml of each of the following unknowns in numbered bottles

Set 1: 0.1 M HCl, 0.1 M $AgNO_3$, 0.1 M NH_4OH

Set 2: 0.1 M Na_2SO_4, 0.1 M $BaCl_2$, 0.1 M KIO_3, 0.1 M $AgNO_3$, 0.1 M Na_2S, 0.1 M KI

1 stirring rod
1 test tube brush (if test tubes are used)
100 ml of each of the following knowns in labelled bottles (it is usually more convenient to distribute knowns by laboratory table rather than group in which case the quantity should be increased accordingly)

Set 1: Unknown Set 1 (above) + 0.1 M HNO_3

Set 2: Unknown Set 2 (above) + 0.1 M $KClO_3$

For the Group

-litmus paper (available at each laboratory table)
-sufficient goggles to ensure that all have eye protection

Comments on Exploration:

Reiterate the safety precautions in the general section for chemistry and make certain that all students and faculty are wearing eye protection.

Demonstrate the use of litmus paper to determine acid-base character, very briefly describe the general problem for the day, and then turn them loose on Set 1 of the knowns. As they begin the experiment, set a time limit which ensures that the exploration will be completed by the end of the first hour of the laboratory period. While circulating through the group, it will probably be necessary to prod them along some. This is neccessary if they are to have time for the entire experiment. Pairs of students who complete the exploration before the end of the designated time period should be allowed to begin consideration of application, i.e. the identification of the unknowns in Set 2.

Comments on Invention:

After the hour for exploration has expired, the group should be assembled for a short group discussion which attempts, without directly telling them what to do, to provide guidance in the analysis of the data. Following this discussion, students should be instructed to continue to work in pairs for no more than 45 minutes in completing the invention phase of the experiment. With a little luck, and guiding questions as the instructor circulates, they will actually do so. As they complete the invention, they should be instructed to proceed directly to application. They should begin the latter with approximately 1¼ hours to remain.

Comments on Application:

Students should be instructed to write down the various combinations they will try before actually beginning to combine solutions. This will enable the instructor to check and make sure (via questions) that they are approaching the problem systematically. It may be appropriate to point out that they will have considerably more data in this experiment than in the first and it is therefore more important that the data be arranged systematically if it is to be interpretable.

Collect goggles at the end of the period and get students to clean their desk area.

3.3e Chemistry: Probability

Name of Experiment:

Simulated Isotope Dilution

General Description:

Pairs of students use dilution techniques to determine the number of beads in a jar. In so doing, they learn to use probabilistic relationships.

Materials Needed:

Per Set of Students

1 large beaker (1000 ml) containing exactly 150 each of red, blue, green, and white beads of equal size and mass
50 yellow beads in a separate container
1 100-ml graduated cylinder
1 ruler
1 large bottle or beaker

For the Group

-balances

Comments on Exploration I:

Describe the general problem, indicate the equipment available to be used in the experiment, and then tell the students they have 15 minutes to complete the activity. During the fifteen minutes, circulate through the laboratory asking the usual kind of questions and/or providing technical assistance as the students use various kinds of equipment. At the end of the time period, ask each group to record their estimate on the chalkboard.

After all data is on the board, tell the students that all the beakers had the same number of items at the beginning BUT DON'T TELL THEM WHAT THAT NUMBER WAS. Then ask them why they didn't all arrive at the exact same estimation. Discuss possible sources of error, uncertainty in experimental determination, etc. Finally point out that the methods used (if based on weighing one item, for example) would not have been applicable if all the items had not had approximately the same mass. Instead, they would have had to use another method. One such method, dilution, will be explored in the next section.

Comments on Exploration II:

Briefly discuss the ideas in the introduction of the section and then get the students started working.

Comments on Invention:

Most of the students will not know how to set up the proportion necessary to determine the total number of items in the container using the data available from the dilution method (Exploration II). As you circulate throughout the laboratory, you should ask the kind of leading questions which will (hopefully) assist them in learning to do so.

Comments on Application:

Each group of students will bring their mixture to you, after removing the yellow beads for you to prepare their "unknown." Do so by removing a small sample of beads from the beaker so that they no longer have an estimate of the number in the container. You should record the composition of the sample removed so the original containers can be easily regenerated for use the following day. Changing the total number of beads forces the students to use the dilution method to complete the application.

3.3f Chemistry: Correlational Reasoning

Name of Experiment:

Shaking the Blues, Chemistry-Style

General Description:

Pairs of students investigate the relationship between amount of glucose or NaOH added to a solution and the amount of time a blue color persists after shaking in order to determine if there is a correlation between the two.

Materials Needed:

Per Set of Students

1 100-ml graduated cylinder
125 ml of 0.5 M NaOH
4 1-gram (+ or - 0.1 gram) pre-weighed packets of glucose (or dextrose) in separate envelopes
1 Erlenmeyer flask
1 cork to fit the flask
1 time piece with a second hand
6 pieces of graph paper (3/student)

For the Group

-sufficient goggles to ensure that all have eye protection
1 small squeeze bottle of methylene blue dye solution (1 gram methylene blue + 65 ml ethanol + 35 ml of water)

Comments on Exploration:

Reiterate the safety precautions in the general section for chemistry and make certain that all students and faculty are wearing eye protection.

Since some of the students have had little or no exposure to laboratory pre-SOAR, exploration should begin by explaining the procedures used in making the solution in Step #1 of the Exploration. This solution should then be tightly corked and shaken to illustrate that doing so does indeed produce a blue color which, upon sitting, dissappears.

The length of time which the blue color persists is somewhat sensitive to method of shaking. Since the students will be asked to pool data, it is important that they agree upon a uniform method of shaking before beginning the experiment. They should be "led" to this conclusion themselves by asking if they think different methods of shaking will make

(continued)

any difference, pointing out that they will have to compare data later, and "guiding" them to remember the control-of-variables experiment earlier in the program. At that time, get all to agree to use an up-and-down shaking motion. Be sure to reiterate the necessity to hold the cork in tightly.

After all data is collected and averaged, it should be recorded on the chalkboard.

Comments on Invention:

The length of time the blue color persists is related to both the concentrations of glucose and sodium hydroxide. However, the technique used in the experiment are sufficient crude to give considerable scatter in the data obtained. This provides an opportunity to discuss problems involved in trying to determine whether or not there is a correlation between two variables. Although the length of time the blue color persists clearly decreases as concentration of either glucose or sodium hydroxide increases, it is desirable to make the graphs so as to obtain some picture of the relationship.

Comments on Application:

The number of seconds of shaking time is not related except, perhaps, for the first few seconds of shaking. The students should have no difficulty in seeing the difference between this lack-of-correlation and the strong correlation from Invention/Exploration.

Make certain that the students clean up their laboratory space before leaving.

3.3a Mathematics: General

Each of the five Mathematics modules is designed to stress one of the five components of problem-solving included in SOAR. Although the content of each is chosen from areas which are useful for students in the sciences, primary emphasis is on the process of working through the laboratory "experiment", i.e. on process. Because of the "laboratory" format, even the very best students benefit from completing the modules (and generally like them). However, the instructor should take care to make certain that the better students are actually analyzing data rather than just relying on rules which they have memorized. This may be discovered readily by the recommended questioning.

3.3b Mathematics: Control of Variables

Name of Experiment:

Relative Sizes of Fractions

General Description:

Students work in pairs using concrete materials to compare the sizes of fractions by varying relative sizes of numerators and/or denominators. In so doing, they become cognizant of the need to control pertinent variables in mathematical problems.

Materials Needed:

Per Set of Students

1 protractor/student
1 straight edge/student
1 construction paper circle/student
1 set of strips with widths proportional to: 22/99, 8/36, 2/9, 6/27, 2/8, 3/12, 1/4, 9/36, 11/44, 12/44, 3/11, 6/22, 27/99
1 set of strips with widths proportional to: 2/13, 6/39, 2/12, 4/24, 1/6, 3/18, 3/17, 6/34, 4/21

For the Group

1 calculator for each student

Comments on Introduction:

Each student is given a protractor, a straight edge, and a circular piece of construction paper. The instructor then assigns each student the task of dividing the construction paper circle into n equal slices where n = 5, 7, 11, 13 (i.e. numbers such that it will be necessary to approximate). The students are allowed to work in pairs or small groups as long as no two in a group have the same value of n. The instructor moves through the class checking to see that each student is able to use the protractor and straight edge in carrying out the task. Assistance is given individually to those students who can't use them, don't remember that there are 360^{0} in a circle, etc.

When all have finished, the students are asked to compare the sizes of each others slices. The instructor makes the following table on the chalkboard and serves as secretary for the class as they attempt to organize their results.

n = number of slices in pie	relative size of pieces	relative size of n
5		
7		
11		
13		

The class, as a group, should arrive at the "answers" in columns 2 and 3. The secretary = instructor prompts the group (if necessary) by questions such as "Which n is largest?," "Which n is second largest?", etc. Eventually the class should reach the conclusion that "larger numbers of slices mean smaller slices."

The students are then asked to answer questions 1-6 in the introduction. The instructor should move around among the students checking each one's answers. Note that question number 6 might be rephrased for students having difficulty as "If each of 17 pies is cut into 16 pieces, how many pieces would there be?"

Comments on Exploration:

The instructor should prepare (in advance) the designated strips of construction paper by cutting varying widths of paper parallel to the short side of the standard-sized rectangle. There should be several copies in different colors of two different sets of strips. The first, set A, should have widths cut proportionally to the fractions:

22/99, 8/36, 2/9, 6/27, 2/8, 3/12, 1/4, 9/36, 11/44, 12/44, 3/11, 6/22, 27/99

The second, set B, should have strips cut proportionally to represent the fractions:

2/13, 6/39, 2/12, 4/24, 1/6, 3/18, 3/17, 6/34, 4/21

The fraction which each strip represents should be written on one side of each strip. One set of strips is needed for each student in class.

The students are to work in pairs. One member of each pair selects a copy of the strips in set A and the other selects a copy of set B--i.e. they select different colored sets. The students are instructed to turn each set of strips face downward so that the fractions cannot be seen. They then arrange the slices (in a given set) in order of increasing size (width) without referring to the numbers written on the strips. They should then read the instructions on the bottom of page 1 and record their data on page 2. Each member of the pair should record his/her fractions under color #1 and to copy the data of his/her partner under color #2.

The instructor checks over the data challenging the students to defend their answers. The bottom of page 2 is straightforward. The student may use pairs of data from either color #1 or #2 in working the problems.

Comments on Invention:

There are four "rules" to be discovered by the students (with prodding by the instructor as needed):

In question #1--"When fractions have equal numerators, the fraction with the larger denominator is the smaller fraction."

In question #3--"When fractions have equal denominators, the fraction with the larger numerator is the larger fraction."

In question #6--"Multiplying numerator and denominator of a fraction by the same number gives an equivalent fraction."

In question #10-- "Dividing numerator and denominator of a fraction by the same number gives an equivalent fraction."

When the students show you their work at the end of page 4, give them two fractions (such as 7/42 and 1/6) and make them show you how one may be obtained from the other.

Comments on Application:

The sample problems were taken from a practice exam for the PCAT (Pharmacy College Admissions Test) and are hence relevant to a sizeable number of SOAR students. It might be well to initiate the Application section by mentioning this. In problems 1a and 1c, the easiest way to compare is to get common numerators. In 1b, it is easier to get common denominators. Question #2 is a more difficult application. You should go through the example with the class as a group, showing how you determine that the given fraction, 8/50, is larger than 1/7 and smaller than 1/6. The pairs should then be allowed to work the remaining three examples independently with assistance (in the form of questions) as needed. It will probably be necessary to constantly remind the students to use the rules which they have "discovered."

The module should be concluded with a group discussion of a "fair test" of a manufacturer's claim of having the bounciest tennis (or ping pong) ball. The instructor has in his/her hands two balls with "A" marked on one and "B" marked on the other. He/she first asks the class how they could test the manufacturer's claim. The usual response is to let the balls bounce and see which one bounces higher. The instructor proceeds to drop one from one height and the other from a different height.

This usually elicits loud responses which state that the test was "unfair." The instructor then proceeds to ask why and, very dramatically, writes on the chalkboard that a "fair test" must include dropping the balls from the same height. The instructor then repeats the test taking great care to drop the balls from the same height but (visibly) applying force to one while merely allowing the other to fall. Once again there will be protests and a second "rule" for a fair test is written on the board. This continues until someone comes up with the concept that <u>all</u> things have to be kept equal <u>except</u> the balls themselves. At the end of the activity, the instructor should ask how this conclusion fits in with the rest of the day's activities.

3.3c Mathematics: Proportional Reasoning

Name of Experiment:

Classification of Plane Figures with Three Sides

General Description:

Students work in small groups (two or three) to investigate the relationship between the ratios of the sides of triangles with equal angles.

Materials Needed:

Per Set of Students

1 table of trigonometric function values
1 metric ruler
1 protractor
1 calculator
1 manila envelope containing right triangles

For the Group

150 construction-paper right triangles with varying side lengths. There should be at least 50 each of 45-45-90, 30-60-90, and 37-53-90 types with at least six different length of sides for each. Each triangle should be given a distinct number on one side. Group into 8 sets and place in manila envelopes.
1 table of trigonometric functions (or a calculator with trigonometric functions) per 4 students
1 metric tape measure
1 cardboard plumb bob/2 or 3 students

Comments on Exploration:

Students should be assigned to small groups of three or so. Each group is to be given a manila envelope with triangles of different sizes and different general shapes. Each group should then measure the three sides and the angles of each and record the data on the first page of the module.

If students have difficulty with question #3, first check to make certain that they have data from at least two kinds of triangles and that they are of varying sizes. Then point out that a) all measurements have some uncertainty (i.e. that none are exact) and b) that a classification scheme doesn't make much sense if it doesn't group items together in some manner (i.e. that a scheme with as many categories as items is a waste of time). With this assistance, they should decide that the only kind of grouping which makes sense is that of equal (as nearly as can be measured) angles. After selecting at least two sets and recording the data at the top of the second page of the module, the ratios should be calculated as stated on the table.

After all students in the class have completed the two tables, draw the outline of such a table on the chalkboard and judiciously choose six or so students to place a row of data on it being sure to choose two examples from each of the equivalent sets. The data can then be used for a class discussion which leads the students to realize a) that the ratios of the sides of triangles with equal angles are the same regardless of the size of the triangle and b) that size of the angle and size of the ratios are somehow related. This should make it possible to answer question 4.

Comments on Invention:

Page 3 is fairly straightforward and should cause no difficulty. Page 4 gives the definitions of the three ratios from trigonometry. The terms "sine", "cosine", and "tangent" should be seen only as names for these ratios.

In question 9, the desired ratios are that of 1/cos A = secant A, etc.

Comments on Application:

Problems 12 and 13 are standard trigonometry problems. A calculator should be provided for finding the trigonometric values. Problems 14 and 15 are more novel but apply the same principles. Specific directions for using the plumb bob are give on page 9 of the module.

3.3d Mathematics: Combinatorics

Name of Experiment:

Counting without Using Fingers or Toes

General Description:

Students work in pairs as they a) learn to use tree diagrams to list the different arrangements of n items, b) use the fundamental principle of counting to predict the number of arrangements possible, c) "discover" the pattern in Pascal's Triangle of binomial coefficients, and d) use use Pascal's Triangle to determine the number of combinations of n things taken k at a time.

Materials Needed:

Per Set of Students

1 geoboard (or equivalent)
1 box of colored crayons

For the Group

1 box of letters of the alphabet
1 large box of different colored rubber bands

Comments on Exploration:

The first activity, making all (6) arrangements of three letters is fairly simple. However, the (24) arrangements of four letters pose a problem. The instructor should examine each group's work and prod them into thinking of keeping the first letter constant while getting six arrangements, the placing another letter in the first position and varying the others to get six more, etc. This can easily be done by suggesting that one set can be obtained by taking the fourth letter and placing it in front of the arrangements obtained in the first activity (that with only three letters). This not only shows the student how the second activity builds on the first, but also helps him/her to find a systematic way of listing arrangements which can be described in words on page 2. The tree diagram on page 3 illustrates another systematic method of determining the various arrangements. The instructor should lead a class discussion about the material on the third page of the module and work the example described at the end of the tree diagram discussion.

Comments on Invention:

The "discovery" of the Fundamental Principle is coaxed from the students by their answering the questions on the fifth and sixth pages concerning the tree diagrams just completed.

Comments on Application:

Problem #3 on page 6 is the crucial one. The students must see that multiplying the number of choices in the stages gives the correct answer, whereas summing does not. It would be well to emphasize this point with each group. The remaining problems are fairly standard applications of the Fundamental Principle.

Comments on the Supplement:

This section contains the material on combinations and Pascal's Triangle. Students usually have difficulty in discovering Pascal's Triangle so it is important that the instructor circulate and constantly ask leading questions. The invention activity describes this in detail.

Students sometimes have difficulty in seeing the connection between the application activity on page 13 and the chart of Pascal's Triangle on page 11. If this occurs, restate problem #1 (page 13) as "Herman really has four pegs and wants to make triangles." The same type of suggestion can be made for the other problems if needed. At the end of the period, you should summarize the data on the chalkboard and spend a little time going over the differences between combinations and permutations.

3.3e Mathematics: Probability

Name of Experiment:

Take Your Chances

General Description:

Students work in groups of four roll dice in order to develop an understanding of probability to the extent that they realize that the probability of a dot-sum in the toss of two dice is found by adding the probabilities of the appropriate pairs and multiplying to obtain the probability of any pairs.

Materials Needed:

Per Set of Students

1 loaded die

For the Group

-nothing

Comments on Exploration:

Each group of students is given a loaded die and told to share the duty of tossing it one hundred times and recording the number of times each sides comes up. When all have finished, four of the groups should be asked to record their totals on the chalkboard so as to fill the first three columns of the following table:

Number of dots	Totals in 100 tosses	Totals in 200 tosses	Totals in 400 tosses	Instructor's 600 tosses	Total in 1000 tosses	%'s
1				186		21
2				102		17
3				102		17
4				102		17
5				102		17
6				66		11

You should then fill in the fourth column with the data listed above pretending that the data came from an actual experiment. The grand totals from 1,000 tosses can then be calculated and the percentages (=probabilities) recorded. The actual percentages should close to those indicated above. A discussion concerning the changing of percentages from 100 tosses to 200 tosses to 400 tosses to 1,000 tosses should be undertaken as a means of leading the students to understand that probabilities predict things for "the long run."

Comments on Invention:

Invention is fairly straight-forward. However, the instructor should lead a class discussion to help generate the theoretical probabilities in question #1. He/she should then circulate in the classroom checking results and asking questions in the usual manner as the students complete the section in groups. The answers for question #1 should be the same as the comparable fraction for 1,000 tosses from the table in Exploration.

Comments on Application:

This section, like the previous, is easily understood. You should pay close attention to question #14 on page 8. Many students have difficulty with the phrase "at least one."

Comments on the Supplement:

The first four questions are straight-forward. Question #5 requires that the students determine that $1/36 = 1/6 \times 1/6$. This type of reasoning reoccurs in question #7. In question #10, the student is to see that $1/36 + 1/36 = 2/36 = 1/18$.

The students should pay close attention to the discussion on page 13. The best method of being sure that they do is for the instructor to lead a group discussion after all have completed page 12.

The remainder of the supplement should present no difficulty.

3.3f Mathematics: Correlational Reasoning

Name of Experiment:

Making Predictions With Graphs

General Description:

Students work individually to arrive at a simple method of measuring the strength of a linear relationship as depected on a graph. This simple method is based on the ratio of the length and width of the scattergram formed by the data.

Materials Needed:

Per Set of Students

1 piece of graph paper
1 metric ruler

For the Group

-nothing

Comments on Exploration:

This is a graphing activity. The students may not have enough familiarity with different types of relationships to know how to answer question #1. If this is so, you should provide a few choices such as straight line, hyperbola, parabola, circle, etc. In question #2, the students should see that small values of x correspond to small values of y and large values of x with large values of y. The strength of this relationship is simply the "opinion" of the student at this stage in the experiment. You should use varying opinions to initiate a discussion of the need for a more accurate (and uniform) method of measuring the strength of such a relationship.

Comments on Invention:

Straightforward.

Comments on Application:

Begin the section with a very brief group-review of the point-slope formula, $y - y_1 = m(x - x_1)$ and $m = (y_2-y_1)/(x_2-x_1)$. Do NOT assume that all students remember it. For the problem in question, point out that the two points must be chosen from those on the line, not from those originally plotted. You should look over the graph for each student to make certain that each has drawn a line that passes as close to the points as possible and not too far from any one point, i.e. that they have drawn the "best" straight line. The graphs should look like the one at the top of page 2.

On page 4, the students should be encouraged to draw a "cloud" around the dots to get the general idea of the type of graph. Note that the two "extraneous" points should be omitted when considering the graph at the bottom left of the page.

Comments on 2nd Exploration:

Straightforward.

Comments on 2nd Invention:

Students should be led to see that their rating of "skinniness" (like 1st skinniest, 2nd skinniest, etc.) matches the W/L ratio better than any other of the measures; that is, that the smaller the W/L ratio the skinnier the cloud.

Commends on 2nd Application:

Straight-forward, no problems envisioned.

3.4a Physics: General

Each of the five physics experiments in SOAR stresses one of the five components of problem-solving included in the program. Primary emphasis was placed on choosing content which would a) illustrate the desired process and b) be of interest to the student. All materials used are readily available in any undergraduate physics laboratory.

3.4b Physics: Control of Variables

Name of Experiment:

Periodic Motion for Fun & Profit

General Description:

Students work in pairs to determine what effect variation of different variables has on a system undergoing periodic motion and in so doing (hopefully) learn that all variables except that under consideration must be controlled during an experiment.

Materials Needed:

Per Set of Students

1 clamp
1 steel strip
6 small magnets
1 ruler
1 stopwatch
1 2"x4" board
2 springs of differing sizes and strengths
1 meter stick
3 weights with masses of 200-gm, 400-gm, and 500-gm, respectively
1 stand to which springs can be attached & hanger to attach weights
1 piece of graph paper

For the Group

-nothing

Comments on Exploration:

Students should be allowed to maniuplate the vibrating system until they think of at least one property that might be affected by changes in other properties of the system. The properties, or dependent variables, that they might suggest include a) how many times the strip swings in a given time interval and b) how long it takes for a certain number of swings.

Before the pairs begin (or while they are) collecting data for Table 1, the instructor should ask each "what property of the system are you testing?" The following is a list of some of the properties whose effects on the system students might investigate: 1) mass of the vibrating body (number of magnets on the strip), 2) length of the metal strip, 3) mode (vertical or horizontal) of swing, 4) distribution of mass, and 5) (often forgotten) the amplitude of vibration.

Comments on Invention:

Make the students defend each conclusion they write by pointing out exactly which data support it.

Comments on Application:

Assist the pairs as they assemble the apparatus by showing them how to hang the spring and attaching a wafer weight on a hanger to the bottom of it.

On page 5 of the exercise sheets, reference is made to "performing operations on the data." Here the instructor should allow the individual pairs to determine the best method of providing the evidence: mathematical calculations, graphs, etc. The student pairs should be given the opportunity to "provide the evidence" on their own. If a pair has difficulty in doing so, you might ask questions such as "which operations do you think might support or prove your conclusion?"

3.4c Physics: Proportional Reasoning

Name of Experiment:

Forces that Move Objects

General Description:

Students work in pairs to determine the relationship between force applied and mass of an object which can be moved by that force.

Materials Needed:

Per Set of Students

1 inclined plane
3 rubber bands
1 meter stick
1 wooden block with a hook on one end
1 pan balance
1 sheet graph paper
-assorted wafer weights totalling up to 300 grams

For the Group

-nothing

Comments on Exploration:

The students should be allowed to manipulate the block, rubber band and meter stick until THEY devise a way of applying a measurable force on the stationary block with the rubber band. The meter stick is used to measure the force, i.e., the stretch of the rubber band.

After each pair of students has concluded that the stretch of the rubber band is a measure of the applied force, ask them questions that will cause them to consider whether the original length of the unstretched rubber band should be included in the recorded values of the stretch.

Through questions, call the students' attention to the details of applying a measureable force:

a) The rubber band should be parallel to the plane on which the block rests.
b) The rubber band should be stretched along the straight line along which the block will move.
c) The applied force should be increased slowly in order to maximize one's ability to know exactly what value of force causes the block to begin to move.

Comments on Invention:

Circulate and make certain that the students answer the questions in the order indicated. Therefore they should answer question #3, hopefully using ratio and proportion, before plotting the graph in #4.

Question #5 should be answered using ratio and proportion because the plotted graph would have to be extrapolated in order to read from it the force necessary to move 700 grams. Questions #6, however, may be answered by either proportional reasoning or from the graph.

Comments on Application:

The activities and questions in #7 attempt to get the students to compare surfaces.

Activities and questions in #8 focus the students' attention on the question" does the number of rubber bands employed make a difference?"

3.4d Physics: Combinatorics

Name of Experiment:

Switch Combinations

General Description:

Students work in small groups (maximum of four in each) to determine which switch or combination of switches in the "down" position will cause a bell to ring.

Materials Needed:

Per Set of Students

1 cardboard box with marked holes
5 switches
1 black button or key
1 power supply
1 bell (or light bulb)
-wire leads

For the Group

-nothing

Comments on Exploration 1:

The instructor should assemble the various switch boxes (one for each group) before the class begins. Each should be wired so that one or more combinations of switches will ring the bell when the black button is depressed. Wire the various set-ups to that different combinations are needed to cause the bell to ring. Be sure to attach wires to all switches, even if they are not a part of the combination that works. When the set-up is ready, place the cardboard box over it with the switches and the black button sticking out through the holes in it. Then mark the switches with the letters R, G, B, Y, and W, respectively, by marking the openings in the cardboard through which they extend.

Circulate through the room asking questions and keeping everyone working. There is sufficient space in Labels Table #1 to record combinations of four or five switches. Indicate to the students that a given combination of switches can be written only once in the table.

Comments on Invention 1:

No problems.

Comments on Exploration 2:

In this and the following section, students study the circuit connections and should discover the difference between complete (closed) circuits and incomplete (opened) ones.

Comments on Invention 2:

The section is very straight-forward.

Comments on Application:

The Application activities are the same as those in Exploration 1 except that each group now works with a new set-up. The diagrams requested on pages 6 and 7 should show how circuit elements are connected or disconnected.

3.4e Physics: Probability

Name of Experiment:

Dice-Atoms Radioactivity Analog

General Description:

Students work in groups of four to use a dice-atoms radioactivity analog to study the probabilistic relationships in radioactive decay.

Materials Needed:

Per Set of Students

1 Dice-Atoms Radioactivity Analog (Madison Associates, Madison, NJ)
2 pieces of graph paper per student

For the Group

-nothing

Comments on Introduction:

Begin the session with a brief introduction to the concepts of radioactivity. Then distribute the analog kits and demonstrate how they simulate radioactive decay. Each die must be marked before giving the sets to students. All of a particular kind should be marked the same. Some groups should have sets of octahedrons with more than one face marked. Question the group as to whether or not this should be taken into consideration in determining the probability that a dot will end UP after shaking the tray. (It should.)

Comments on Exploration 1:

This section is rather straight-forward. There should be no problems.

Comments on Invention 1:

On page 3, for the equestion concerning two dice landing with each having a marked face UP on a single throw, the instructor will probably have to tell the students that this simultaneity of events requires the multiplying of the individual probabilities.

The last question on page 3 may cause difficulties. If so, it may be restated as "What is the probability of the first die turning up a red-dotted face, the second die turning up a red-dotted face, ... and the 100th die turning up a red-dotted face on a single throw of the 100 dice?"

You will have to demonstrate how a percent error is calculated when the groups reach page 5. This can be done for the entire class at one time if they are proceeding at the same pace or with separate groups as they finish if not.

Comments on Exploration 2:

On page 6, it may be more deisrable to do inter-group averages, i.e. averages between groups I and III, etc. rather than a class average since all groups may not be proceeding at the same pace.

This section is the first in which the students are actually simulating radioactive decay. When all complete it, the class should be re-assembled and some follow-up of the introductory remarks should be made in order to make sure that the students understand the connection.

Comments on Invention 2:

The two lines of the graph (on page 6) represent the rate of a) decay of the parent and b) growth of the daughter.

The fourth and fifth questions on page 7 attempt to get the student to recognize that a certain constant number of throws is required to reduce the number of parent atoms in a radiocative sample to one-half of its original number regardless of the number of atoms (dice) with which one begins. This constant number of throws is the analog of the half-life of a radioactive element.

Comments on Application:

This experiment is rather long. All students may not complete it in the three-hour period. Keep each group working steadily and don't worry if they don't finish. You will have to judge what to expect as you work through it.

The decay scheme on page 8 involves a radioactive parent-radioactive daught-stable end product.

The printed matter in the Dice-Atoms Analog Kit included decay and growth curves to which students should compare their experimental curves. The comparison curves are selected, of course, on the basis of the number of marked faces on the dice in the student's set. The instructor should make these prepared curves available for students to use after they have constructed their own curves.

3.4f Physics: Correlational Reasoning

Name of Experiment:

Electric Circuits That Don't Shock

General Description:

Students work in groups of three or four to measure power supply voltages, potential differences between points in a circuit, resistances, currents, and lengths of wire in order to determine what (if any) relationships exist among the quantities.

Materials Needed:

Per Set of Students

1 meter lengths of different kinds of wire
1 power supply
1 milliammeter (0-250 ma)
3 voltmeters: one 0 - 1 volt, and two 0 - 10 volts
2 C-clamps
1 plastic meter stick
1 resistance box (0-999)
1 piece of graph paper
-key
-leads

For the Group

-nothing

Comments on Exploration:

The instructor should make certain that each student learns to handle the instruments properly and to accurately read each measuring device at the very beginning of the period. Students SHOULD NOT be allowed to "plug in" a power supply or make any measurements UNTIL the instructor has checked the connections in the circuit. You should pay special attention to the way the ammeters are connected and must make certain that the recommended ranges of power supply voltage and resistance not be exceeded.

A plastic meter stick (figure 1 on page 2) gives more reliable results than does a wooden one.

Comments on Invention:

When soliciting proof of discovered relationships (page 6), give hints such as suggesting graphing, mutiplying, dividing, etc. only after given each set of students ample opportunity to try to come up the ideas themselves.

Comments on Application:

Begin the section with a brief discussion of the resistance color code for the class as a whole. It is not necessary for the students to memorize the code; they merely have to learn to use it.

The Application can be completed without the voltmeter connected across the resistance (see figure 2).

INSTRUCTIONS FOR COMPUTER PROGRAMMING

4.1 Instructors

For four days each week, SOAR participants spend mornings (three hours from 9 a.m. to 12) completing the Piagetian-based laboratory exercises in Biology, Chemistry, Mathematics, and Physics described in preceding sections of this manual. The fifth three-hour morning session of each week is devoted to learning to program in BASIC. The text for this portion of SOAR is Computer Programming in the BASIC Language, Brother Neal Golden** (Harcourt Brothers, Dallas).

Each group of SOAR participants (from 25 to 30 in each) will have five three-hour computer programming sessions. Most will have had little or no previous exposure to the computer. Therefore, the beginning of the first class period should be devoted to making certain that all students know how to log on and off of the computer as well as how to call up the various games which are available. Current instructions from both may be obtained from the manager of the computer systems.

Class format should generally allow time for lecture, for in-class studying, and then practicing what is learned. Since there will generally be from 8 to 10 terminals available for use by the class, each group of SOAR students should be divided into subgroups for the purpose of completing assignments. Each subgroup should develop the designated program at the work tables in the CCL*, then one person from the subgroup should proceed to the terminal to type the program into the computer. Upon completing typing and running the program, he/she should return to the subgroup with the printout where results can be discussed. This procedure should ensure that there is no delay in obtaining a terminal to use. When complete, each subgroup should submit their program to the instructor for evaluation.

There are sufficient copies of the text to make it possible to distribute one to each student in class each day. However, since the same books must be used by another group of students the following day, students may not remove the texts from the classroom.

Upon completion of the assignment for the day, students will have access to the games on the computer. Since games change from time to time, it will be necessary for the instructor to contact the computer systems manager as to what is available at a given time.

*Centralized Computing Laboratory. The instructor should reserve the interactive terminals and the use of the room for SOAR in advance.

**A faculty member at Brother Martin High School in New Orleans.

INSTRUCTIONS FOR COGNITIVE THERAPY

5.1 General

All instructors must attend the three-hour orientation to cognitive therapy at the beginning of the program. This workshop will cover the first three chapters of Problem Solving and Comprehension by Whimbey and Lochhead (Franklin Institute Press, Philadelphia) in the following format:

30 minutes	Participants complete the WASI (pages 5-12).
45 minutes	Director "debriefs" the group by going through the exam while analyzing mistakes made (or anticipated) and illustrating good problem-solving protocols.
90 minutes	Director leads a discussion of Chapters II & III concluding with an emphasis on pages 30-31 of the 2nd Edition (pages 33-35 of the 1st) which explains the classroom format to be used.

The general philosophy of cognitive therapy is that good problem-solving is characterized by slow careful step-by-step analysis, constant attention to detail, continual checks for mistakes, and use of pencil and paper (for diagrams, notes, etc.) as often as possible. Speed or "being able to solve it in your head" are NOT components of good problem-solving and are actively discouraged. The mechanisms used to promote good problem-solving are a) monitoring the students' thinking as they work to be certain they are sufficiently careful and b) demonstrating "good" protocols.

Each 1½ hour cognitive therapy class is divided into two 45-minute segments which stress (separately) verbal and quantitative reasoning. The two are referred to as "analytical reasoning" and "problem-solving", respectively. The basis format of each is as follows:

Analytical Reasoning: In class students work in pairs (a listener and problem-solver) solving problems in Problem Solving and Comprehension (and similar materials) as described on pages 30-31 (2nd Ed.). After completing each problem, the student checks his/her solution with the detailed one in the text or presented on the chalkboard. Textbooks may not be removed from the classroom but the SOAR notebook contains homework related homework assignments which will be collected and graded.

Problem-Solving: As students begin each chapter in the text, Algebra: An Introductory Course by Bramson (AMSCO), they should work individually. As the better prepared ones complete the exercises, they will be assigned the role of "tutor" and allowed to assist the less well prepared ones. Any part of an in-class assignment which is not completed during class will be assigned as homework.

The following schedule specifies both the in-class and homework assignements in the analytical reasoning and problem-solving for the program:

Week	Day	Analytical Reasoning Classroom/Homework	Problem-Solving Classroom/Homework
1	W	Administer WASI (30 minutes), then debrief the students going through and helping them, as a group, analyze their mistakes. The latter should take no more than a hour. Conclude the analysis of mistakes by going through the summary on pages 20-22 (both editions) of Problem Solving. Finally, spend about 30 minutes discussing Chapter III of the text with emphasis on the methods of good problem solvers and the listner/problem-solver pair format to be used in class. Assign pages 47-64 (Chapter 4) of Algebra as homework.	
	Th	"Verbal Reasoning*"/ #1	Algebra 4/ pages 65- 77
	F	....Test on "Verb. Reason."	....Test on Chapter 4
2	M	"Verbal Reasoning*"/ #2	Algebra 5/ pages 78- 86
	T	" or Anal. Rea.#8/ #3	" 5/ pages 87- 97
	W	"Analogies*" / #4	" 5/ pages 95-101
	Th	" / --	" 7/ pages 122-130
	F	....Test on "VR" & "Anal."	....Test on Chapter 5
3	M	"Writing Re. Sen.*"/ #5	Algebra 7/ pages 131-138
	T	" / #6	" 7/ pages 139-148
	W	"Form Analogies*" / #7	" 9/ pages 178-188
	Th	" / --	" 9/ pages 189-198
	F	....Test on "WRS" & "FA"	....Test on Chpts. 7 & 9
4	M	"Trends & Patt.*" / #8	Algebra 2/ pages 16- 22
	T	" / #9	" 2/ pages 23- 29
	W	"Math Word Probs.*"/#10	" 3/ pages 30- 37
	Th	" / --	" 10/ pages 199-212
	F	....Test on "T & R" & "MWP"	....Test on Chpts. 2 & 3
5	M	Anal. Reasoning #1 /#11	Algebra 10/pages 213-223
	T	" #2 /#12	" 11/pages 224-235
	W	" #3 /#13	" 11/pages 236-247
	Th	" #4 / --	" 12/pages 248-256
	F	....Test on "AR"	....Test on Chpts. 10 & 11
6	M	Anal. Reasoning #5 /#14	Algebra 12/pages 257-261
	T	" #6 /#15	" 13/pages 262-268
	W	" #7 / --	" 13/pages 269-273

*Chapter in Problem-Solving and Comprehension.

ANALYTICAL REASONING HOMEWORK ASSIGNMENTS

Homework #	Assignment for 1st Edition Prob. Sol. & Comp. (In SOAR Notebook)	Assignment for 2nd Edition Problem Solving & Comprehension (In text unless designated other.)
1	Pages 31-32, Problems 1-10	Pages 121-122, Problems 1-10
2	Pages 32-33, Problems 11-20	Pages 122-124, Problems 11-20
3	Page 51, Problems 1-15	Pages 124-127, Problems 21-35 & Problems 41-42
4	Pages 24-26, Problems 1-15	Pages 179-182, Problems 1-12
5	Pages 12-14, Problems 1-19	Pages 182-184, Problems 13-24
6	Pages 15-17, Problems 1-18	Page 4 (4 SATs*), Problems 16-25, Form Code 8B210
7	Pages 54-55, Problems 1-20	Make up ten analogies of your own being sure to write relationship sentence.
8	Pages 24-25, Problems 1-10	
9	Pages 25-26, Problems 11-15 & Problems 1-5, Page 27	
10	Pages 27-28, Problems 6-15	Pages 301-304, Problems 41-50
11	Pages 3-8, Problems 1-40 (4 SATs*) Form Code 8B210	Same as for 1st Edition
12	Pages 9-12, Problems 1-35 (4 SATs*) Form Code 8B210	Same as for 1st Edition
13	Pages 13-16, Problems 1-45 (4 SATs*) Form Code 8B210	Same as for 1st Edition
14	Pages 17-20, Problems 1-25 (4 SATs*) Form Code 8B210	Same as for 1st Edition
15	Pages 3-8, Problems 1-40 (4 SATs*) Form Code 0B023	Same as for 1st Edition

Appendix IV contains answers to homework problems for 1st Edition.

*4 SATs (Scholastic Aptitude Tests), 1980 College Entrance Examination Board, Educational Testing Service, Princeton, NJ.

5.2a Group Leaders: Analytical Reasoning

The analytical reasoning segment is designed primarily to teach the participants how to solve problems. Therefore, we are much more interested in knowning how an answer was obtained than in the answer itself. As the instructor in these sessions, it therefore important that you watch to see that the students keep working in pairs using the step-by-step procedure of approaching problems and carefully explaining (to their "listener" partner) what they are doing at every step of the way. You should make the students consult the problem-solving protocols in the textbook in order to get an idea of the amount of detail that is required. (Please note that is is a lot.) As the students work, you should circulate through the classroom providing assistance and keeping everyone working. To provide some variety in the classroom, you may occasionally stop the class and get some individual to go over a particularly difficult problem for the entire class. This would, of course, replace referring to the written protocol (if available). Use the chalkboard as much as possible in such endeavors.

In pairing students, you should attempt to place well-prepared ones with those who are less capable. The easiest way to accomplish this is to use performance on the weekly test as a method of determining who will be paired with whom. In assigning pairs, be careful to be positive about the entire process--i.e., not to hurt anyone's feelings. Feel free to use the "good of the group" as a convenient excuse to get the desired persons to work together.

The following are some specific comments about the various classroom assignments in the analytical reasoning segment:

PS&C IV --Work through the introduction with the entire class. Then assign pairs and circulate to keep them working. Be sure that the listener/problem-solver relationship is working--i.e., that the listener is making the problem-solver go into sufficient detail.

PS&C V* --As with chapter IV.

PS&C VI* --As with chapter IV.

PS&C VII* --As with chapter IV. MAKE CERTAIN THAT EACH STUDENT WRITES THE SENTENCE TWICE WHEN SERVING AS "PROBLEM-SOLVER", ONCE WITH EACH WORD PAIR.

PS&C VIII* --As in VII making certain that each student writes the relationship sentence with blanks when serving as problem-solver.

PS&C IX* --Same as VIII.

*Chapter numbers are from the 1st Edition of Problem-Solving and Comprehension. The equivalent chapters for the 2nd Edition are IV = IV, V = X, VI = IX, VII = VI, VIII = VII, IX = VIII with 1st edition listed before 2nd in each pair.

Analytical Reasoning Exercises--Exercise #8 is pages 34-37, problems 21-42, in the SOAR notebook. Exercises 1-7 are reading passages from five sets of materials of which only limited copies are available. They are paired so that 1 & 2, 3 & 4, etc. are the first and second half of one set of materials. At the beginning of the fourth week, you will be given one of the five sets. Use the first half of your set for the 1st AR exercise and the second half for the 2nd. Then pass your set of materials to the group leader with the next higher group number ("1" is "higher" than "5" for this purpose). By doing so you will get a new set every two days. The materials may NOT be taken from the classroom. Each exercise consists of reading passages and a set of related questions. The pairs of students should complete the passages as in other parts of analytical reasoning. As the instructor, you should circulate to make certain that all are working. Stop the entire class occasionally and allow one student to discuss answers for one passage at the chalkboard.

There are fifteen short homework assignments for the analytical reasoning segment. You should collect and grade each on a 10-point scale.

You should keep a record of the points from homework, from in-class activities (10 points each day for attending and working diligently), and from the Friday tests. Students should be told that the participants with the highest number of points in analytical reasoning will receive awards at the end of the program. The maximum number of points which they may earn are:

15 short homework assignments, 10 pts @	150 pts
20 in-class activities, 10 pts @	200 pts
6 tests (on Fridays), 50 pts @	300 pts
Total	650 pts

Finally, you should note that you are a member of your group and will be taking the tests on Friday. It might therefore be worthwhile for you to work through the materials also.

5.2b Group Leaders: Problem-Solving

The problem-solving segment is designed to give the students a chance to use the techniques they are acquiring during analytical reasoning activities while, at the same time, reviewing the basic mathematics they will need in order to do well in freshman mathematics and science courses. The text for the segment is Algebra: An Introductory Course by Bramson (AMSCO). As the students begin each chapter, they should be working individually (or in small groups if needed to get the poorer ones moving). As the better prepared students finish the assigned work, give them the title of "tutor" and designate a less well-prepared student for them to assist. If a given assignment is not completed during class, assign the remainder of the section as homework. During class circulate through the classroom providing assistance and watching carefully to make sure that everyone is really working rather than just copying answers. If you allow one student to monopolize your time for ten or so minutes, then you aren't doing your job. Students should tear out and turn in each assignment after it is completed. Return it to them after "grading" (checking over to see if they are working the problems) on a 10 point scale.

Keep a record of each assignment completed and of points obtained by performance on Friday tests. There will be awards for the students with the highest scores in the problem-solving segment at the end of the program. The maximum number of points available are:

20 in-class activities, 10 pts @	200 pts
6 tests, 50 pts @	300 pts
Total	500 pts

Finally, you (as a member of your group) will be taking the tests with your students on Fridays.

5.2c Group Leaders: Tutorial Sessions

There are 30-minute tutorial sessions at the beginning and end of each day. During the first week, all students must attend. In subsequent weeks, those who score "140" (70%) or better on the Friday tests are exempt from attending. Use the tutorial sessions to review and/or complete work from the analytical reasoning or problem-solving segments. When these are complete select assignments from the extra (homework) problems in the SOAR notebooks or from the following sections of the supplemental books available:

Breaking the Reading Barrier: Pages 170-179, 186-188, 114-118, 189-190, 213-215, 231-232, & 191

Six-Way Paragraphs: Articles 4, 9, 11, 12, 79, & 90

At the end of each Friday competition, there will be a 30-minute group meeting during which time you should hand out answer sheets, look over problem areas, and organize the tutorial program for the upcoming week.

5.3 Supervisor: Analytical Reasoning & Problem-Solving

The primary responsibilities of the supervisor are:

1) To meet with the group leaders at 10:00 a.m. each day (for about 15 minutes) to reiterate what should be done for the day and to discuss problem areas.

2) To drop into each group's classes at least once per week to make sure that all is progressing as it should. Be sure to note if the group leaders are following the schedule, actually circulating around the room as they should, etc. Report any problems to the director.

3) To prepare the following quizzes for the competitions:

	Analytical Reasoning	Problem-Solving
1st Friday	5 problems "Verb. Reas."	5 problems from 4
2nd Friday	5 problems "Verb. Reas." 5 problems "Analogies"	5 problems from 5
3rd Friday	10 problems "Analogies"	10 problems from 7 & 9
4th Friday	5 problems "Trends" 5 problems "Math Word"	5 problems from 2 & 3
5th Friday	Reading segment w/ 10 questions	5 problems from 10 & 11
6th Wednes.	Use standard tests from director	

4) To keep the director informed of what's happening daily.

INSTRUCTIONS FOR VOCABULARY

6.1 General

One half of an hour on Monday through Thursday is devoted to vocabulary-building using Vocabulary for the College-Bound Student by Levine (AMSCO). The schedule is as follows:

Week	Day	Assignment
1	W	Vocabulary, pages 3-16
		" "
2	M	Vocabulary, pages 17-23
	T	" "
	W	" , pages 24-31
	Th	" "
	F	Vocabulary Test II
3	M	Vocabulary, pages 32-38
	T	" "
	W	" , pages 39-47
	Th	" "
	F	Vocabulary Test III
4	M	Vocabulary, pages 48-60
	T	" "
	W	" , pages 61-70
	Th	" "
	F	Vocabulary Test IV
5	M	Vocabulary, pages 71-80
	T	" "
	W	" , pages 81-93
	Th	" "
	F	Vocabulary Test V
6	M	Vocabulary, pages 112-127
	T	" "
	W	" , pages 143-156
	Th	Vocabulary Test VI
	F	Cumulative Vocabulary Test

6.2 Group Leaders

The first vocabulary assignment will be made on the first day the students begin, i.e. the first day of orientation. At that session, you should pronounce each of the words, get the students to repeat them as a group, explain about the Friday competitions (beginning immediately), and then assign the exercises on pages 3-16 for the next competition as homework. The first competition will only be for practice but don't bother to tell the students this. Having a competition early will give them the general idea and will provide motivation to work hard the following week.

Two class days are allotted for each of the subsequent assignments in the text, Vocabulary for the College-Bound Student by Levine (AMSCO). The format for the two days is as follows:

Day 1 — Pronounce the words for the entire section, making the students repeat them after you. Assign all exercises as homework for the following day.

Day 2 — Make the students tear out and turn in homework as they enter the classroom. Then "grade" it (on a 20-point scale) while administering a short quiz (from Appendix V) which spot-checks knowledge. Utilize the remainder of the class time in sentence construction using items not in the text. This should not just repeat the drill which they could have done alone, but rather should be fill-in-the-blank sentences, situations for which the students provide appropriate words, etc. Return the homework to the students at the end of the period.

Homework (20 points maximum for each), in-class activities (20 points each), and performance on the tests on Fridays should all be recorded. The participants with the best scores at the end of the program will receive awards. The maximum number of points which may be obtained are:

10 homework assignments, 20 pts @	200 pts
10 quizzes, 20 pts @	200 pts
6 tests, 100 pts @	600 pts
Total	1,000 pts

You should be very careful to adhere to the official schedule which allows 30 minutes Monday through Thursday for vocabulary. If additional time is needed, use some of the tutorial session.

Finally, you will be required to take each vocabulary test with your group and your score will count, like those of your students, toward your group's total score in the competition.

6.3 Supervisor

The responsibilities of the coordinator of the vocabulary-building component of SOAR are:

1) To meet with the group leaders at 10:00 a.m. each day to make sure all know what to do and to discuss problems.

2) To drop into each group's class at least once per week to be sure that the group leaders are following instructions. Place close attention to whether or not they are adhering to the time schedule and conducting the session without merely repeating what is in the text.

3) To prepare seven vocabulary tests, including the practice one and the cumulative final.

4) To keep the director of the program informed of the various groups' progress.

INSTRUCTIONS FOR QUIZ BOWL COMPETITIONS

7.1 General

The "quiz-bowl" competitions are designed primarily to motivate the students to work as hard as possible in the afternoon components of SOAR. In order to make certain that all participants work, major emphasis in determining the winner in the competition is placed on group performance. It is therefore important to get each group to "coalesce" and to start working together as soon as possible.

There are three parts of each competition as follows:

- A 30-minute, objective analytical reasoning/problem-solving test worth 100 points (50 points for each segment)
- A 30-minute, objective, 100-question vocabulary test worth 100 points
- A 45-minute oral competition for which the rules are contained in Appendix II

All members of each group (including the group leader) will be required to take the two written tests. While they are being graded, four members of the group will represent the group in the oral competition. At the end of this section, the total points for each group will be calculated using the formula,

$$\text{Pts for group} = \text{Pts from oral comp.} + \frac{(\text{Total written pts})}{(\text{\# in the group})} \times 25 = ,$$

and the group with the highest total score will be declared the winner. That group will be allowed to keep the SOAR trophy for the week. Please note that "# in the group" above is the number who should have been there, not the number who actually showed up--i.e., that absences hurt the entire group.

7.2 Group Leaders

Each group leader is expected to:

1) Explain the competitions to your group on the first day of orientation, including going over the rules for the oral competition in Appendix II.

2) Prepare you group for the competitions using the suggestions in earlier sections of this manual.

3) Get all of your group to stay in the program all summer and to work hard.

4) Get the members of the group to the room where the competition will be held on time.

5) Get your group seated and pass out answer sheets to them.

6) Get members of your group to set up the table and chairs which your group will use in the oral competition AND TO REPLACE THEM IN THE STORAGE ROOM AFTERWARD. Note: There is a 500 point penalty for forgetting to put them away.

7) Take the written tests and do well.

8) Select the members of the group to participate in the oral competition. You, as group leader, are not eligible.

9) Lead the group in cheering their team's efforts in the oral competition.

10) Protect the reader and all other instructors from competition-crazed SOAR participants.

11) Generate competition with other groups.

12) Remember that it is all just a game.

7.3 Supervisor

The supervisor for the quiz-bowl is expected to:

1) Go over the rules for the oral competition with the group leaders before the first one.

2) Obtain a guest reader for each weekly competition by Tuesday of each week.

3) Provide each reader with a copy of the guidelines in Appendix III on Tuesday.

4) Prepare 25 questions for the reader to use covering the vocabulary for the week by Tuesday at noon.

5) Select a secretary to record scores for the oral competition.

6) Direct group leaders (and members of the groups) as they arrange the tables and chairs for the competition.

7) Administer the written exams.

8) Protect the reader during the oral competition.

9) Have a good stiff drink about 3:00 p.m. every Friday afternoon.

7.4 Graders

The entire process of attempting to grade all of the written tests rapdily enough to announce the weekly group winner at the end of the oral competition requires at least two persons working in coordination. Grading should begin as soon as the first written exam is complete. With a little luck, it will be possible to grade and record this set of papers by the time the second written exam is ready. This then allows time to grade the second set while the oral competition is in progress. The specific responsibilities of the graders are to:

1) Grade each test using the key provided using the electronic grader in the APLC.

2) Add the scores for each group and record in the form in Appendix III (the competition form).

3) Compute the scaled score for each group.

4) Record individual student scores on the summary sheets (Appendix I).

5) Xerox a copy of the summary and the competition forms and give to each group leader as soon as you return to the competition.

6) Record the scores from the oral competitions onto the competition forms.

7) Give the original copies of the competition and summary to the director.

8) Pray (often) that the electronic grader doesn't break down.